MACMILLAN'S CANADIAN SCHOOL SERIES

A LABORATORY MANUAL IN CHEMISTRY

CORNISH AND SMITH

Gertrude Catherine Sharp.

John Oliver

High School.

MACMILLAN'S WESTERN SCHOOL SERIES

A LABORATORY MANUAL

TO ACCOMPANY

CHEMISTRY

A TEXT-BOOK FOR HIGH SCHOOLS

BY

GEORGE A. CORNISH, B.A.

ASSISTANT PROFESSOR IN SCIENCE, COLLEGE OF EDUCATION, UNIVERSITY OF TORONTO AND CHIEF INSTRUCTOR IN SCIENCE, UNIVERSITY SCHOOLS, TORONTO

Assisted by ARTHUR SMITH, B.A.

CHIEF INSTRUCTOR IN PHYSICS, CENTRAL TECHNICAL SCHOOL, TORONTO

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CONTENTS

LABORATORY MANUAL

GENERAL INSTRUCTIONS TO THE PUPILS

1. Each exercise must be read carefully from the beginning to the end before the operation is begun. All apparatus should be prepared, and all materials should be on hand before the actual operation takes place, so that the pupils may be able to give their whole attention to observing the phenomena.

2. Every word in the sections entitled METHOD has been inserted for a purpose, and the pupils must not vary in the least from the directions there given. The quantities of reagents indicated must be strictly adhered to in order that the pupils may complete the experiment successfully and rapidly.

3. The questions must be studied carefully before the performance of the experiment is begun, as they frequently direct the attention to phenomena that might otherwise escape observation, and that can be observed only while the experiment is under way. The questions can be answered only after careful thought and close observation. In order to answer some of them, information not furnished by the experiment is required, and in such cases reference is generally made to a section of the text-book where the additional information can be obtained. The references to the sections in the text-book are printed in black-face type.

4. Wherever in the sections entitled METHOD the word "Technic" is inserted, the pupils must turn to the corres-

ponding section of this Manual under "Technic" to find the proper directions. Pupils must never omit reading the directions in "Technic".

5. The answers to the questions at the end of each exercise are to be recorded in the Science Note-book, but not as a series of fragmentary, unconnected answers. They are to be combined and written as a continuous series of statements, properly arranged to show the reasoning by which the pupil passes from the observation to the conclusion.

6. If the pupils drop acid on their clothing, ammonium hydroxide should be at once applied to the spot.

7. If a finger is cut it should be washed clean under a tap, then bathed in a solution of boric acid, and finally bound with a piece of clean cotton.

8. If a burn is caused by a chemical or by contact with a hot object, it should be bathed in a picric acid solution and dressed with soft cloth moistened with the same solution. Scalds are treated like burns.

9. Wherever in an exercise a number occurs in square brackets such as [1], [2], [3], an observation is to be made and recorded in the science note-book. The observation may be that nothing happened.

TO THE TEACHER

1. This Manual has been prepared for the pupils' use, and in selecting the exercises the small schools with limited equipment have been kept constantly in mind. Accordingly, the greater number of the exercises require only the simplest apparatus; in fact, the only special apparatus necessary, besides balances, is one or more good blast lamps. Where the laboratory is not equipped with gas, it will be necessary to use blast lamps that burn kerosene or gasolene.

2. The Manual contains no demonstration experiments to be performed by the teacher, as these are out of place in a pupils' Manual. However, a considerable number of such experiments are fully described in the text-book, embodied as a part of the descriptive matter. These experiments are either too difficult to be performed by the pupils or require too expensive apparatus.

3. In preparing a Manual it is difficult to determine how complete to make the instructions. In order that an experiment may be of most benefit, the pupils should be led to see the problem to be solved by the experiment and to suggest the method by which the experiment should be performed. Skilful questioning by the teacher, preliminary to the performance of the experiment, is the best method of attaining this end. In order to assist the teacher, such questions, therefore, have been introduced either as preliminary questions or as questions on a preceding experiment. Nevertheless, much supplementary questioning by the teacher along the same lines will be necessary in order to achieve the best results.

4. Assuming such preliminary questioning, the instructions have been made so complete that they will require little or no explanation or addition by the teacher in order that the pupil of average intelligence and skill may be able to perform the experiments successfully. Indeed, everything has been done that will tend to lessen the work of the teacher, as he requires all his energy to oversee the work, and he should not at every stage be obliged to supplement the directions of the Manual.

5. The questions are of two kinds—those that direct the pupils to matters of fact to be observed in the experiment itself, and those that involve reasoning on the part of the pupils. To answer the latter questions, knowledge of other facts besides those observed in the experiment is

frequently required, and to assist the pupils in acquiring this knowledge references to the text-book are frequently given.

6. There are many manipulations, such as filtering, evaporating, testing with litmus, etc., which pupils have to perform quite frequently, and which, though once learned, are soon forgotten. Instead of inserting directions in the exercises themselves for the carrying out of these operations, such directions are inserted together on pages 5-20 under "Technic", and the pupils are referred to them in each exercise where the operation has to be performed. In this way much repetition in the directions is prevented. However, after an operation has been repeatedly performed, the reference to "Technic" is omitted, it being assumed that the pupils have by that time learned the operation.

7. At the end of most of the chapters are placed some Additional Optional Practical Exercises. Some pupils perform experiments much more quickly than others, and in such circumstances it is sometimes difficult to know what to do with such pupils in order to keep them engaged. It is intended that they should be set to work on these optional exercises, which, being closely related to those already performed, require no detailed instructions. These additional exercises can sometimes be used as alternative exercises to those fully described in this Manual.

8. A drawer containing material for emergencies should always be provided. Gauze bandages of various widths, a pair of scissors, boric acid solution (one half saturated), picric acid solution for burns (see page 2), smelling salts, and adhesive plaster will be most frequently required.

9. A vessel containing sand should be kept in a convenient place. If alcohol, carbon bisulphide, or any

other inflammable liquid is spilled on the bench and ignites, it can readily be extinguished by placing sand on the burning liquid. Water will usually spread the flame.

TECHNIC

1. Preliminary questions.—The ordinary experiences of daily life bring many phenomena under the casual observation of the pupils. Accordingly, some of these phenomena do not require to be presented in this Manual by means of experiments in order to be of use to the pupils and to supplement the knowledge gained by experiments. The preliminary work in the Manual is inserted for the purpose of bringing these phenomena to the notice of the pupils in order that they may relate them to the experimental work already completed or about to be performed. The answers to the preliminary questions should be thought out by the pupils before they come to the class and should be discussed in the class before the pupils begin the experiments.

2. Final paragraph.—The answers to the questions at the end of each exercise are to be recorded in the Science Note-book. They are not to be recorded, however, as a number of fragmentary sentences, but are to be combined in a series of statements properly arranged to show the reasoning by which the pupils pass from the observation to the conclusion.

3. Handling phosphorus.—Yellow phosphorus should never be touched, as it is likely to be ignited by the heat of the fingers and to cause a bad burn, difficult to heal. Unless yellow phosphorus is specially indicated, red phosphorus should always be used. When, however, yellow phosphorus is required to be used, the teacher should handle it with forceps, cut off the pieces

under water, and put them in the pupils' evaporating dishes containing water. The pupils should remove the yellow phosphorus from the water on the point of a pin and dry it on filter paper just before using it in an experiment. Any phosphorus left unburned should be carefully removed from the vessels in which it is used and placed in a special receiver. It should never be thrown into the vessel used for waste materials.

4. Handling sodium and potassium.—Sodium and potassium are kept under kerosene, as they are destroyed by contact with the air, and if they touch water an explosion may result. Consequently pupils should be very careful in handling sodium not to touch it unless the fingers are quite dry, otherwise a severe burn may be the result. Calcium also, for the same reason, should not be handled with wet fingers. As potassium ignites very readily pupils should not be allowed to take it in their fingers at all.

5. Blast lamps.—For many operations it will be necessary to use a lamp which will give a more intense heat than does an alcohol lamp or a Bunsen burner. In laboratories not supplied with gas, these operations will require kerosene or gasolene blast lamps. Where gas is available either blow-pipes or Meker burners, number A, may be used.

6. Use of pipette.—To use a pipette, place the pointed end of it in the liquid, the other end in the mouth, and by suction draw the liquid into the pipette well above the mark on the stem, being careful, however, not to draw the liquid up into the mouth. Then quickly place the first finger over the upper end of the pipette at the same time as it is withdrawn from the mouth. If the liquid has dropped below the mark the operation must be repeated. Then gently ease the finger in con-

tact with the upper end of the pipette and allow the liquid to drop slowly until its surface is even with the mark on the pipette. To do this successfully the finger must be dry. Then let the liquid flow into the vessel, draining out the last drop by touching the tip of the pipette to the side of the vessel.

7. Use of burette.—In measuring volumes with the burette, several points must be observed. The graduations in cubic centimetres, unlike those of a graduate, read from the top to the bottom. Note what volume is contained in the space between two adjacent graduations. See that there are no air bubbles in the nozzle. If the burette has a pinch-cock the bubbles can be removed by turning the nozzle up and allowing the liquid to flow for an instant. If the burette has a tap the bubbles can be removed by allowing a little of the liquid to run out. In reading the level, place a white card behind the burette, and keeping the eye level with the surface, read the lower line of the meniscus (Fig. 1).

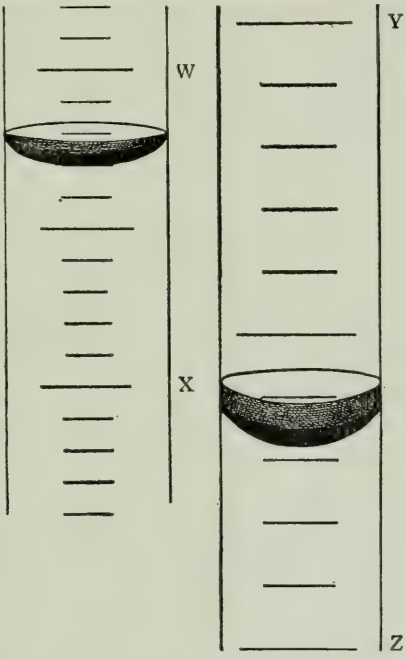


FIG 1

8. Separating funnels.—If the laboratory is not supplied with separating funnels, it is easy to make

satisfactory substitutes as follows: Cut off a thistle-tube leaving the stem about 2 in. long and round off the sharp edges in a flame. Then by means of a piece of soft rubber tubing, connect the cut end of the thistle-tube with a piece of glass tubing 7 in. long. Make the rubber tubing of such a length that the end of the stem of the thistle-tube and the end of the glass tubing inserted in the rubber are 1 in. apart. Now insert in this inch of rubber tubing a large lead shot, or a solid glass bead cut from a piece of glass rod and rounded in the flame, taking care that the bead or shot is so tight that there is no leakage of liquid around it. The liquid may be made to flow by pinching the rubber tube at the side of the bead or shot. A pinch-cock on the rubber tube, however, may be used instead of this device.

9. Use of hoods.—Operations where bad-smelling or irritating gases are generated should be performed in a fume closet or in a hood on the bench. Form the habit of always working close to the hood during such operations.

10. Splints for gases.—Burning matches should not be used for inserting into gas bottles in order to observe if the gas within supports combustion. Often matches are too short, and as they have a number of combustible substances on them, the results obtained may be confusing. Instead of matches use wooden splints 6 in. long, either purchased for this purpose, or made by splitting the sides of crayon boxes.

11. Measuring gas volumes.—When the volume of a gas collected over water is to be measured, the water in the pneumatic trough should stand until it has reached the temperature of the room. Before the gas is measured, the level of the water in the trough and within the gas bottle should be at the same height. Place a sheet of

glass under the mouth of the gas bottle, remove the bottle from the trough, and place it on the bench with the mouth up. Now measure by means of a graduate the volume of water necessary to fill the bottle. This is equal to the volume of the gas.

12. Measuring volumes of liquids.—It is frequently necessary to measure out roughly a certain volume of liquid. Each pupil should find out by means of a graduate how many cubic centimetres an ordinary test-tube will hold. Since a test-tube is 5 in. x $\frac{5}{8}$ in. contains about 25 c.c., therefore, 5 c.c., 10 c.c., etc., can be approximately measured by filling one-fifth, two-fifths, etc., of the test-tube. By means of a graduate the volume of a beaker should also be found, in order that the pupils may be able to measure larger volumes approximately.

13. Dropping tubes.—To measure out drops of a liquid, first pour some of the liquid into a test-tube, then insert a pointed tube into the test-tube and suck up some of the liquid. Next place the first finger over the upper end of the tube and gradually loosen the finger until a drop forms at the point of the tube. Be careful that the point of the tube is never dipped from one liquid into another, or the latter will be polluted. An eye dropper or a fountain-pen filler can be used for the purpose.

14. Collecting gases by displacement of water.—When gases are to be collected over water proceed as follows: Run water into the pneumatic trough to a depth of about 1 in., fill the gas bottle completely with water, place over the mouth of it a piece of paper just large enough to cover the opening, and then turn the mouth of the bottle down in the trough, and the paper will float off. To collect the gas, place a bottle in a corner of the pneumatic trough and tip the bottle enough to place the rubber delivery tube under its mouth. The gas bubbling

up outside the bottle indicates that it is full. The delivery tube should then be placed under the mouth of another bottle. Unless the pupils are directed otherwise they should leave the bottles of gas mouth down in the pneumatic trough until required to be used in the experiment.

15. Collecting gases by displacement of air.—Gases soluble in water and lighter than the air are collected by downward displacement of the air (Fig. 2). If the gas is heavier than the air and soluble in water, it is collected by upward displacement of the air (Fig. 3). In both cases the delivery tube should pass nearly to the bottom of the gas bottle. Why?

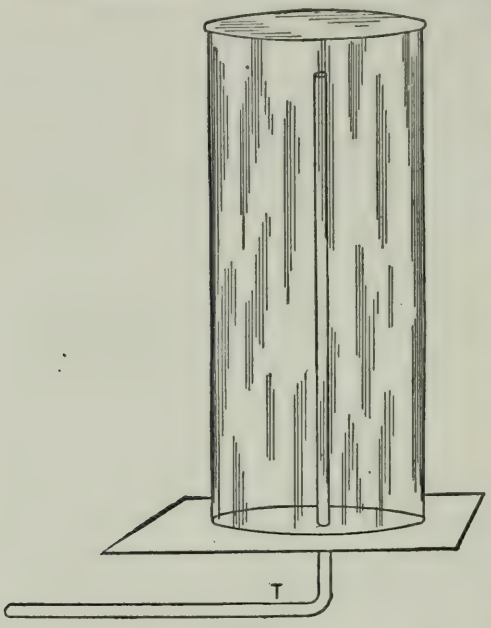


FIG 2

16. Testing solubility of solids.—Test the solubility of a solid as follows: First, place the powdered substance in a test-tube and add one inch of distilled water; second, shake the test-tube thoroughly for two minutes and then filter the liquid (Technic 19); finally, place on a clean watch-glass one drop of the filtrate and beside it, but not in contact, one drop of equal size of distilled water. Each

drop should be not more than one-half inch in diameter when measured on the glass. By comparing the amounts of the deposits left by the two drops after they are evaporated, decide if the substance is insoluble, slightly soluble, quite soluble, or very soluble. In order to evaporate the filtrate, encircle with the thumb and first finger the watch-glass and hold it over a low flame until the water has evaporated (patience!). Unless the glass is held in this way pupils are likely to bring it down too close to the flame and thus break it.

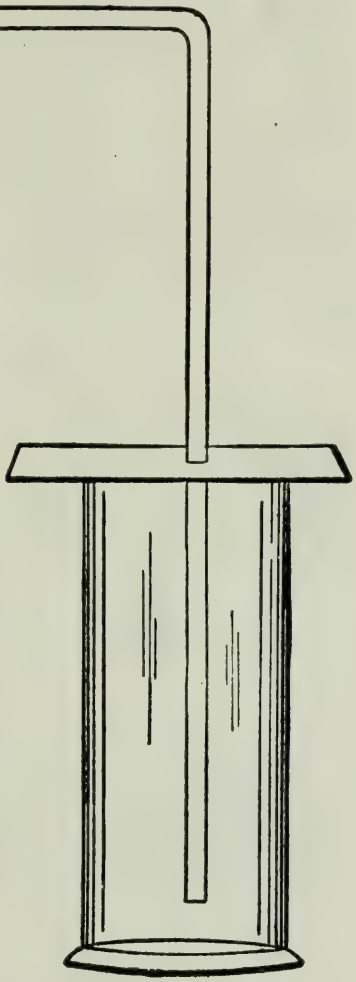
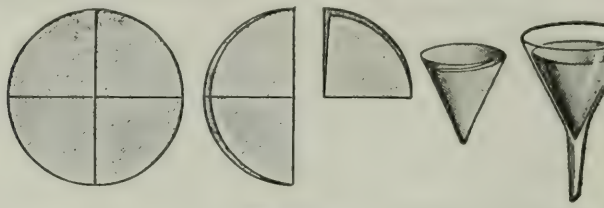


FIG 3

17. Testing the solubility of a gas. —To test if a gas is soluble in water, fill a test-tube with the gas, pour in one inch of water, quickly place the thumb tightly over the mouth of the tube, and

shake it for one minute. The amount of suction on the thumb indicates the solubility.

18. Saturation of liquids with gases.—After the gas has been bubbling through the liquid for some time, put the thumb on the end of the test-tube and shake it for one minute; if there is no suction on the thumb the solution is saturated. Why? If there is suction the solution is unsaturated, and the gas requires to be passed through the liquid for a longer time.



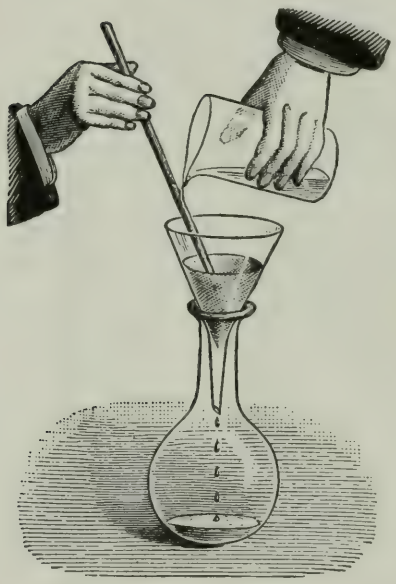


FIG 4

19. Filtration. — Use a circular filter paper which when folded does not reach quite to the rim of the funnel. Fold it along a diameter (Fig. 4), then fold it into quarters along a radius. Next separate it at the edge, having three folds on one side and one fold on the other, and insert it into the funnel. Now wet the paper with distilled water, so that it

will not absorb large quantities of the solution to be filtered, and see that it adheres close to the funnel. Place the funnel in the ring of a retort stand with the bottom of the stem in contact with the side of the test-tube or beaker into which the liquid is to be filtered. Now pour the solution into the funnel. If the filtrate does not come through clear, pass it through the same filter paper again. Never allow the stem of the funnel to dip into the filtrate. A filter paper is used for one filtration only.

20. Crystallization.—To prepare crystals of a salt proceed as follows: Make a moderately strong, warm solution of the salt; if it is not perfectly clear filter it and set a watch-glass nearly filled with the solution aside for a day. When the water has evaporated examine the salt under a strong lens, and well-formed crystals will be found in some part of it. Make drawings of a number of the crystals.

FIG 5

21. Sand-bath and water-bath.—Evaporation of solutions of solids in liquids should never be carried out over a naked flame, since in the final stages the solid is liable to be decomposed by excessive heat. The evaporating dish should be placed on a sand-bath, made by putting one-half inch of sand in a circular iron dish about 5 in. in diameter and 1 in. deep (Fig. 5). The flame should be extinguished before the salt is completely dry, as there will always be enough heat in the dish and the sand to drive off the last traces of the water. In some cases

where more careful heating is necessary a water-bath must be used. A suitable water-bath is shown in Figure 6: a beaker is set on wire gauze on the ring of a retort stand, and in the beaker is placed water to a depth of 1 in.; the evaporating dish is laid on top of the beaker, a match or a splinter of wood being placed between the two so that the steam can escape freely. At least half an inch of water should be kept in the beaker, otherwise the glass is likely to crack. Too much water, however, should not be used, on account of the time required to bring it to the boiling point. A shallow beaker will accelerate the rate of evaporation.

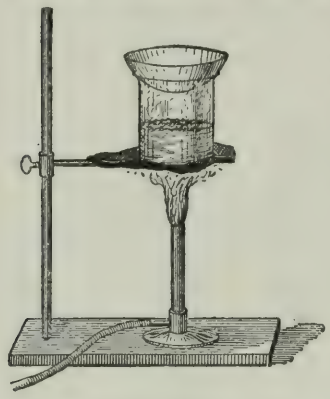


FIG 6

22. Testing air tightness.—To find out whether a Florence flask with a thistle-tube and delivery tube is air-tight, blow through the delivery tube until the liquid rises two or three inches in the thistle-tube, then pinch the delivery tube; if there is a leak in any part the liquid will gradually drop in the thistle-tube. To test whether a Florence flask or test-tube, with a delivery tube only, is air-tight, suck the air out through the delivery tube till the tongue is sucked in against the opening; if there is a leak the suction on the tongue gradually diminishes.

23. Inserting tubing in a cork.—To insert a glass tube through a cork, the tube and the opening in the cork should be wetted, and the tube should not be pushed straight through the cork but should be continually rotated back and forth while it is being inserted. Vaseline

may be used with ordinary corks, but it is very injurious to rubber. Glass tubes should be removed from rubber corks immediately after an experiment.

24. Flame test.—To find what colour a substance gives to a flame, place the substance to be tested in a crucible and pour a little pure hydrochloric acid on it, but not enough to dissolve it; then bring the colourless flame of a Bunsen burner down on the salt and watch for the tinge of the flame which is reflected from the salt. If the laboratory is not supplied with Bunsen burners put the salt in an evaporating dish, add a little hydrochloric acid, then a little alcohol, stir the mixture, and ignite the alcohol. Watch for flashes of colour, especially when the alcohol is nearly all consumed. The colour will show best in a dimly lighted room. An alternative method is as follows: Make a small loop on the end of a piece of thin iron wire, hold the loop in the flame until it is red hot, then withdraw it and put in the loop a lump of the solid to be tested. Hold the solid in a colourless flame and observe the tinge it gives to the flame.

25. Drying test-tubes.—A test-tube can be dried rapidly as follows: Insert one end of a piece of clean, dry cheese-cloth 4 in. wide and 1 ft. long into the tube, turn the cloth around with a lead-pencil to wipe up the water, then insert a rubber tube into the test-tube, and by means of a bellows force air through the test-tube until it is quite dry.

26. Putting a powder into a test-tube.—Cut a piece of stiff, glazed paper an inch longer than the test-tube and slightly wider than the diameter of the test-tube, fold the paper lengthwise along the middle to form a trough, distribute the powder along this trough; then

holding the test-tube horizontal, place the trough inside the tube and carefully tip the latter up until all the powder has slid down to the bottom of the test-tube.

27. Testing with litmus.—Except where a different method is specifically stated, testing with litmus should always be conducted as follows: A piece of red litmus paper and one of blue, both as large as the little finger nail (but no larger), are placed in the liquid to be tested, where they are left for five minutes unless some change is evident sooner; if there is any doubt as to whether either of the pieces has changed, two similar pieces are put into water, which does not change their colour, and by comparing the two reds and the two blues any change produced by the liquid being tested will be noticed. Where gases are being tested with litmus it is necessary first to moisten the litmus paper. While experimenting, do not let litmus lie out on the bench top, and do not handle it with wet or dirty fingers.

An alternative method of testing with litmus, which must be used if the liquid to be tested is coloured or contains a precipitate, is as follows: Put a piece of red litmus paper and a piece of blue on a sheet of glass and by means of a glass rod put a small drop of the liquid on each of the pieces of paper; in a minute wash the liquid off and examine the papers for a change of colour.

28. Washing a precipitate.—When a precipitate is filtered out of a solution, the filter paper retains not merely the insoluble material but also a part of the solution, which fills the pores of the paper and adheres to the particles of solid. Therefore, if the material on the paper is merely dried, it is not entirely free from the soluble substance. Accordingly, to get rid of the soluble material entirely, it is necessary to add distilled water to the filter paper and to allow the liquid to pass

through; this is repeated until all the dissolved material is washed through. Such an operation is called "washing the precipitate."

29. Pouring acids into sinks.—Residues from acids or from strong alkalies, if they are dumped into an empty sink, injure both the sink and the water pipe. Therefore, before such residues are emptied into the sink, it should be partly filled with water to dilute the acid or alkali, and the tap should be left running in order to sweep the corroding substance out of the waste-pipe.

30. Mercury residues.—As mercury dissolves lead or copper, and, consequently, will rapidly eat a hole through piping, this metal should never be poured into a sink. A bottle, labelled "impure mercury", should be provided by the teacher, and all residues of mercury left from experiments should be poured into this bottle. This mercury can afterwards be cleaned and used.

31. Inserting substances into bottles containing gases.—Great care should be exercised in placing substances in bottles or test-tubes containing gases, in order that as little gas as possible may escape. The substance to be inserted should be brought close to the mouth of the bottle before the cover is removed, and the cover should be removed just enough to slip the substance in, and then should be at once replaced. If a deflagrating spoon is being inserted into a bottle of gas, the same precautions should be observed.

32. Heating glassware.—If liquids are heated in beakers or flasks, the vessels should be placed on wire gauze centred with asbestos and the heating should only gradually be raised to the maximum. The liquid should never be allowed to fall low in such vessels, nor should the flame be allowed to strike the glass above the level of the liquid. A solid should never be heated in a beaker, flask,

or ordinary test-tube. Solids may be heated, however, in hard-glass test-tubes. As the latter are thicker than ordinary test-tubes, great care is necessary in order not to break them. A test-tube while being heated should always be held obliquely, should be brought down gradually into the flame, and at the end of the operation should be gradually withdrawn from the flame. A suitable test-tube holder is made by folding a sheet of paper to make a narrow strip, which is placed like a collar (Fig. 7) around the test-tube near the top. The test-tube is held, by means of the projecting ends of the paper, in the left hand, and is turned continually by the right so as to heat all sides of it equally. Where the test-tube has to be heated for a considerable time, it may be fastened by a clamp attached to a retort stand. When a solid is being heated in a test-tube there is danger of melting the glass; the melting of the tube is indicated by the flame turning yellow; accordingly, when this warning colour appears in the flame the intensity of the heating should be reduced.

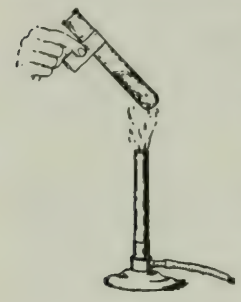


FIG 7

33. Smelling gases.—When directed to smell a gas, begin cautiously. Keeping the mouth closed, with the hand draw a whiff of the gas toward the nostrils. If there is no perceptible odour the nostrils may be brought closer until the smell is detected.

34. Tasting substances.—In tasting substances it is neither necessary nor wise to take a mouthful. Bring a little of the substance on the tip of the finger to the tongue. As soon as the substance has been tasted expel

it from the mouth into the sink and rinse the mouth with water.

35. Use of delivery tube.—A delivery tube is used to allow gas to pass from a generator into a receiver. As a glass delivery tube is too rigid, usually a glass elbow tube is inserted in the cork of the generator, and a rubber tube is attached to it.

If the gas is being passed into a liquid, a glass tube should be inserted in the free end of the rubber tubing in order that the rubber may not dip into the liquid. But where the gas is being collected in a gas bottle by the displacement of water, the rubber tube alone should be used.

36. To break a piece of glass tubing.—Make a scratch on one side of the tubing with a single stroke of the edge of a triangular file. Place the hands as in Figure 8, with the thumbs on the side opposite to the scratch. Then bend it toward the thumbs.

FIG 8

37. To make a pointed glass tube.—Hold the glass tubing above the inner cone as in Figure 9, and constantly rotate the tubing until it becomes soft. Remove the tubing from the flame and at once draw the two ends apart, slowly at first and then quickly; the tubing should assume the shape shown in Figure 10. Then with a stroke of the file cut off each part so as to leave one half inch of the drawn-out part on each tube.

FIG 9

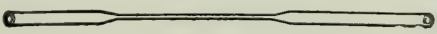


FIG 10

38. To bend a glass tube.—This operation cannot be performed properly by the pupils in the ordinary flame of either a Bunsen burner or of an alcohol lamp. The Bunsen burner should be provided with a "wing top" so as to give a broad, yellow flame. Hold the glass above the dark inner part of the flame as in Figure 11, and keep the tube rotating until it is soft enough to bend, then remove it from the flame, and at once bend it to the required angle (Fig. 12). If bent properly it should not be creased in at the bend, but the bore should be as large at the bend as in the straight part of the tube.

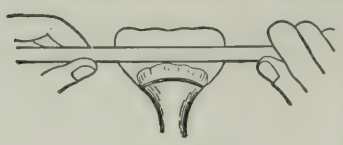


FIG 11

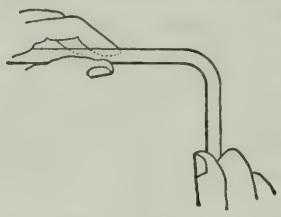


FIG 12

39. Heating a residue to constant weight.—It is frequently necessary to decompose or separate substances by heat, one of the products being driven off as a gas, the other remaining as a residue. In order to be certain that the operation is complete the residue must be weighed, then heated and weighed again. These operations must be continued until two successive weighings are the same

CHAPTER I

BURNING IN AIR

EXERCISE I

Preliminary Work (Technic 1)

1. Write in your Science Note-book a list of six or more substances that you have seen burn; select some solids, some liquids, and some gases, and have the substances as varied in character as possible. Devoting a short paragraph to each substance, describe the phenomena of burning. These paragraphs should contain answers to the following questions, as well as any other observations worthy of note:

(*a*) Is the burning accompanied by a flame?

(*b*) Is the burning accompanied by light?

(*c*) What kind of substance, if any, is left?

(*d*) Is the substance left the same in properties as the original substance?

(*e*) Does the substance left appear to weigh more or less than the original substance?

(*f*) Do you think anything else was formed besides the visible ash? Give reasons for your opinion.

(*g*) Was anything necessary for the burning besides the substance and the match used for ignition?

2. Write a short paragraph summarizing the general characteristics of burning to be deduced from a comparison of the observations recorded in 1 above.

3. Do substances begin burning spontaneously, or do they require to be ignited? How are they ignited?

4. Do the substances all begin to burn at the same temperature? Try at home to light with a red-hot poker, paper, shavings, a kerosene lamp, and the gas from a gas jet.

5. Is there anything necessary besides more fuel, to make a substance burn well?

6. What is the difference between heating and burning?

EXERCISE 2

To study what happens when magnesium is heated

REQUIRED. Crucible, triangle, retort stand and ring, Bunsen burner or alcohol lamp, emery-paper, magnesium ribbon.

METHOD.

1. Clean with emery-paper the magnesium. Note its colour, lustre, hardness, flexibility, etc. [1].

2. Put the magnesium ribbon into a crucible without a lid, place the crucible on the clay triangle, resting on the ring of the retort stand, and heat the crucible until all action ceases [2].. It may be necessary, if alcohol lamps are used in the laboratory, to heat with a blast lamp (Technic 5). Not the colour, lustre, flexibility, etc., of the substance left after heating [3].

3. Scrape out the contents of the crucible, and if necessary in order to make it clean, scour it thoroughly with moist powdered pumice or fine sand. A stain in the crucible will not injure it for future use.

QUESTIONS: A. Is the substance remaining different from the original one? B. Does the substance left look like a single substance, or like a mixture of substances? C. What do you

think has become of the original substance? Give a reason. D. Do you think the substance after heating is lighter, heavier, or of the same weight as the original substance? E. If the substance after heating is lighter than the substance before heating, what possible explanations can you give of the decrease in weight? F. If the substance after heating is heavier, what possible explanation can you give? G. How would you find out experimentally whether there is an increase or a decrease in weight?

EXERCISE 3

To find if magnesium when heated in air changes in weight and to find whether it increases or decreases in weight

REQUIRED. Crucible and lid, clay triangle, retort stand and ring, crucible tongs, balance, Bunsen burner; magnesium ribbon.

METHOD.

The magnesium ribbon should be cleaned with emery-paper. The crucible should be thoroughly cleaned before the metal is placed in it.

1. Place 10 cm. of magnesium ribbon rolled up loosely in a crucible. Weigh the crucible, lid, and metal [1].

2. Place the covered crucible on a clay triangle, set the latter on the ring of a retort stand, heat the crucible very strongly (Technic 5). Carefully raise the lid a little every half minute until the metal ceases glowing brightly when the lid is raised, then heat the crucible strongly with the lid off for 10 minutes.

3. When cool, again weight the crucible, lid, and substance together [2].

4. Clean the crucible as in the preceding exercise, (3).

QUESTIONS: A. How would you account for the increase in weight? B. How would you prove whether any substance had been absorbed by the crucible? If the teacher approves of your method, try it. C. Assuming that there was no

absorption from the triangle into the crucible, what substances were the crucible and metal in contact with from which absorption might have taken place? D. From the fact that it was necessary to raise the lid occasionally in order that the magnesium might burn, which would you infer had been absorbed, something from the air or something from the flame? E. How could you prove experimentally whether air is necessary in order that magnesium may change when it is heated? F. After describing fully in your Note-book the foregoing experiment, write a final paragraph (Technic 2) containing answers, written in logical order, to the foregoing questions.

EXERCISE 4

To find if the magnesium of Exercises 2 and 3 is changed when air is excluded

REQUIRED. Crucible, lid, clay triangle, retort stand and ring, Bunsen burner, magnesium, some clean sand or bone-ash.

METHOD.

1. Place about the same quantity of magnesium as was used in Exercise 3 in a crucible and almost fill it with clean, dry sand or bone-ash, and put on the cover. Weigh the crucible, substance, sand, and cover [1].

2. Heat the crucible strongly for ten minutes, without raising the lid or stirring the sand.

3. After allowing the crucible and contents to cool without disturbing them, weigh them again [2]; then take off the sand and examine the substance to find if it has changed [3].

QUESTIONS: A. Is there any marked change in weight, as there was when the magnesium was heated without being covered with sand? B. What is the only difference in condition in this and in the preceding Exercise, assuming that the sand remains passive during the reaction? C. Explain why there is a small amount of change on the surface of the magnesium

after it is heated. D. Do you think sand or bone-ash changes its weight on being heated? Suggest an experiment to prove whether it does, and if time permits perform it. E. Explain why in Exercise 3 it was necessary to raise the lid when the magnesium was being heated.

EXERCISE 5

To study the effect of heating mercury oxide—the substance formed by heating mercury in air

REQUIRED. Hard-glass test-tube, splint, Bunsen burner, crucible; mercury oxide.

METHOD.

1. Place in the bottom of a hard-glass test-tube as much mercury oxide as will lie on a ten-cent piece (Technic 26). Heat the test-tube very strongly [1] (Technic 32). Note the changes in colour of the powder as it is heated [2]. Note the appearance of the substance that collects on the sides of the test-tube [3].

2. When a deposit begins to form on the sides of the test-tube, light a splint (Technic 10), shake out the flame so as to leave only a spark on the end, and slowly insert the glowing splint into the test-tube [4]. Repeat this several times [5].

3. Continue heating the test-tube until a glowing splint will not rekindle when it is inserted into its mouth. Allow the test-tube to cool, rub down the deposit from the sides with a piece of paper, turn the deposit out into a crucible, and examine it carefully [6]. Identify this substance [7].

4. Pour the mercury in the test-tube (Technic 30) into the bottle labelled "impure mercury" provided by the teacher and clean the test-tube with hot nitric acid (caution!).

QUESTIONS: A. How is mercury oxide formed? B. How many substances did you obtain from the mercury oxide? C. Which one came originally from the air? D. In this Exercise what properties of this component of air can be observed? E. How does the gas that comes off differ from air? F. How does this exercise confirm your conclusion that when metals are heated in air they absorb a part of the air? G. Make a closing paragraph which includes answers to questions A to F. See that each statement of the paragraph leads logically to the succeeding one (Technic *2*).

CHAPTER II.

AIR AND ITS COMPONENTS

EXERCISE 6

To prepare a supply of oxygen and to study some of its properties

REQUIRED. Hard-glass test-tube, one-holed rubber cork, delivery tube, three gas bottles, deflagrating spoon, litmus paper, watch-glass, funnel, filter paper, asbestos paper, sheet of glass; potassium chlorate, manganese dioxide (dried by heating in a crucible for a few minutes), charcoal, sulphur, picture wire, sodium. Where laboratory periods are short 1 and 2 may be done during the first period and 3 and 4 during the succeeding period.

METHOD.

1. Mix on a paper three parts of potassium chlorate and one part of manganese dioxide. Prepare enough of the mixture to fill 1 in. of the hard-glass test-tube. Fit up apparatus as in the illustration (Fig. 13); have the top of the test-tube a little lower than the bottom; see that the materials are spread along the test-tube as shown in the illustration. Begin heating carefully, drive off the gas from the materials nearest the mouth of the tube, and gradually work toward the base. As the gas tends to come off violently, the pupils must try to regulate the flame so as to obtain a steady stream.

Do not collect any gas till a spark, when held at the mouth of the delivery tube, glows; then collect over water three bottles of the gas (Technic 14). Be sure that the flame is never withdrawn from under the test-tube while the mouth of the delivery tube is in the water; accordingly, when the contents of the test-tube are exhausted, first remove the mouth of the delivery tube from the water, then remove the flame from under the

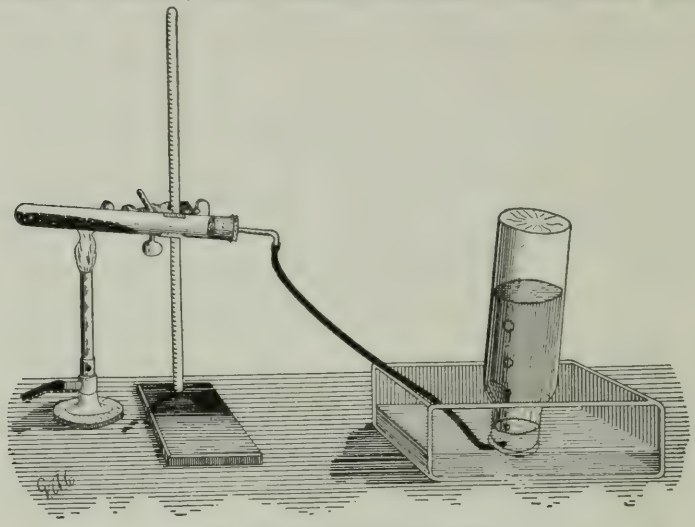


FIG 13 PREPARATION OF OXYGEN

test-tube. The test-tube can be cleaned by soaking it in water. After allowing a bottle of the gas to stand for a few minutes, note the appearance and the smell of the gas in the bottle [1].

2. Place a sheet of glass under the mouth of a bottle of the gas, remove it from the pneumatic trough, and place it on the bench top with the mouth up and covered by the glass. Then place a pinch of sulphur in the

deflagrating spoon, having previously lined the spoon with asbestos paper, adjust the cap to such a height that, when the spoon is placed nearly to the bottom of the gas bottle, the cap rests on the mouth. Place the spoon in a flame till the sulphur begins to burn, remove it, and note the colour, size, and brightness of the flame in air [2]; then place the spoon in the jar of oxygen (Technic 31), and note the change in the flame [3]. After the flame is extinguished remove the spoon and smell the gas [4] (Technic 33). Pour 10 c.c (Technic 12) of water into the bottle, place the palm of the hand firmly over the mouth, and shake the bottle vigorously for half a minute; then test the liquid with litmus [5] (Technic 27).

3. Treat sodium and charcoal in exactly the same way as sulphur was treated in 2 [6]. Add water as in 2 and in the same way test with litmus [7].

4. Loosen the strands of a piece of iron picture wire about 10 in. long, dip the frayed end into a little melted sulphur, heat this end until the sulphur on the wire begins to burn, and then lower it into a bottle of oxygen [8]. The bottle should have one inch of water in the bottom, otherwise it may crack. When combustion is complete, remove the burnt iron that has dropped to the bottom of the bottle, and note its colour, brittleness, and any other differences as compared with the original wire [9]. Wash the burnt wire under the tap, grind it up, and test it with litmus [10] (Technic 27); also test its solubility [11] (Technic 16).

5. Burn all the above substances (except iron) in bottles full of air [12]. Note the character of the product in each case, and test as before the solutions of the products with litmus [13].

QUESTIONS: A. Is it possible to decide whether the oxygen came from the potassium chlorate, or from the manganese dioxide, or from both? B. How would you prove from which of the two substances the oxygen came? C. What differences are there in the way the substances burn in air and in oxygen? D. Explain why the burning is more intense in oxygen than in air (**Sec. 16**). E. Explain why iron burns in oxygen but not in air. F. Classify the oxides formed by burning the foregoing substances in air, in respect to the action on litmus of their aqueous solutions. G. Make drawings of the apparatus used in the preparation and collection of oxygen. Write a paragraph discussing the nature of the reactions taking place when oxygen is generated.

EXERCISE 7

Preparation and properties of nitrogen

REQUIRED. Florence flask, two-holed rubber cork, thistle-tube, elbow tube, delivery tube, 5 gas bottles, pneumatic trough; ammonium chloride, sodium nitrite phosphorus, sulphur, magnesium.

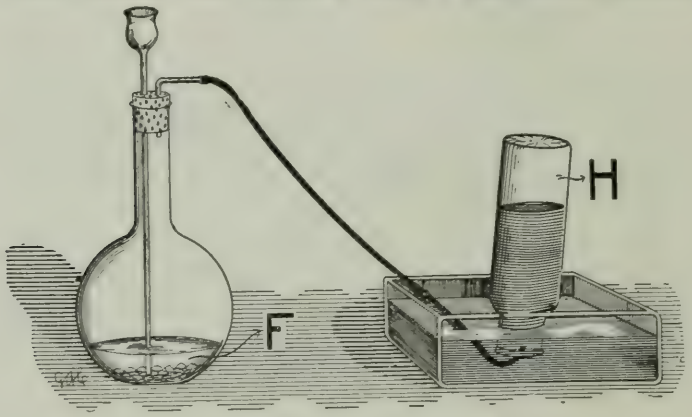


FIG 14—PREPARATION OF NITROGEN
F. Flask containing ammodium chloride and sodium nitrite. H bottle in which nitrogen is collected.

$NH_4Cl + NaNO_2 \rightarrow 2H_2O + NaCl + N_2$

1. Arrange apparatus as in Figure 14. Place about 8 grams of ammonium chloride and an equal amount of sodium nitrite in the flask and add enough water just to cover the solids. Be careful that the bottom of the thistle-tube is below the surface of the water. Find whether the apparatus is air-tight (Technic 22). Heat the flask *gently* (Technic 32) until the gas begins to come off, then remove the flame, as the gas will now come off of its own accord [1]. If the gas comes off too violently, set the flask in a vessel of cold water. After the air has been driven out of the apparatus collect four bottles and a test-tube full of the gas.

2. Note if the gas has any colour or odour [2].

3. Let the pupils test if the substances that burned in oxygen will burn in this gas, each pupil trying two of the substances [3].

4. Using the test-tubeful of gas, note if it is soluble in water [4] (Technic 17).

5. Note if the gas is heavier or lighter than air [5]. Do this as follows: Remove two bottles from the trough, hold one with the mouth up, the other with the mouth down, and every half minute insert a burning splint into each until a difference of behaviour is observed.

QUESTIONS: A. What properties of nitrogen are observed in this experiment? B. Make drawings in your Note-book illustrating the method of preparation.

EXERCISE 8

To find the percentage of oxygen and nitrogen in air

REQUIRED. Gas bottle, pneumatic trough, iron filings, cheese-cloth, wire, graduate.

METHOD.

1. Tie a small tea-spoonful of iron filings in a small cheese-cloth bag, and after moistening them with water,

tie the bag to a glass rod. Insert the glass rod into a gas bottle full of air and invert the bottle over water in a pneumatic trough (Fig. 15).

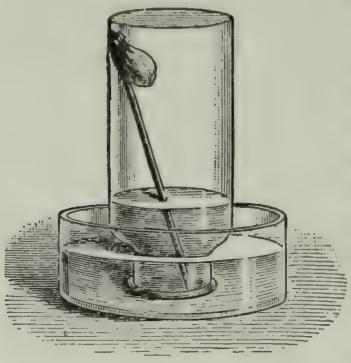


Fig 15

2. After the bottle has stood in a warm place for two or three days, adjust it so that the water is at the same level inside and outside the bottle, and mark with a piece of gummed paper the level of the water in the bottle [1].

3. Leaving the iron filings in the bottle, measure the volume of water contained in the bottle when it is filled up to the gummed paper [2], and measure the volume of water contained when the bottle is completely filled [3].

Questions: A. From the volumes measured in 3 calculate the percentage of the two gases in the air (assume that the iron extracts all the oxygen and does not affect the nitrogen). B. Why were the iron filings left in the bottle when the water was added? C. What could have been used, instead of the iron filings, to absorb the oxygen?

CHAPTER III

SOME CHEMICAL LAWS

EXERCISE 9

To find if the total weight of substances changes during a reaction

REQUIRED. Florence flask, a small test-tube that can be placed within the flask, rubber cork, balance; concentrated solutions of the following pairs of substances: barium chloride and sodium sulphate, potassium carbonate and calcium chloride, potassium hydroxide and ferrous sulphate, sodium chloride and lead nitrate.

METHOD.

1. Let each pupil select one pair of the foregoing reagents and place 10 c.c. (Technic 12) of one in the Florence flask and 10 c.c. of the other in the test-tube, being careful that no liquid adheres to the outside of the test-tube. Into the flask lower the test-tube, keeping its mouth up in the neck of the flask. Insert a rubber cork tightly into the flask and weigh the flask with its contents accurately [1].

2. Tip up the flask so that the contents of the test-tube run out and mix with those of the flask [2], then weigh the two again [3].

QUESTIONS: A. Has a chemical change (**Sec. 29**) taken place? B. Has any substance entered or left the flask? C. As a result of the reaction is there any change in weight? D. As a result of the experiments performed by all the class, what conclusion can be drawn as to the total weight of the reacting substances before and after the reaction?

CHAPTER IV

WATER AND HYDROGEN

EXERCISE 10

Preliminary Work (Technic 1)

1. Have rain-water, river-water, spring-water, and sea-water exactly the same properties?

2. If not, to what is the difference in properties due?

3. Are they pure substances or mixtures (**Secs. 26, 28**)?

4. What do you mean by pure water? How could it be obtained from these different kinds of water?

5. What evidence is there that air contains water?

6. Name some substances that give off water when they are heated.

7. When bread dries does it lose water? Name other substances that dry in the same way.

8. At home put a kettle of cold water on the gas stove, keeping the bottom perfectly dry. Then light the gas and observe if drops of a liquid like water form on the bottom of the kettle.

EXERCISE 11

To find the effect of putting metals in water

REQUIRED. Watch-glass, test-tube; sodium, calcium, litmus paper.

METHOD.

1. In order to drive off all dissolved gases, boil for ten minutes a Florence flask half-full of distilled water. Cool the water and set it aside for use with the metals mentioned.

2. Into a test-tube containing one inch of the boiled water drop a piece of sodium (Technic 4) about the size of a grain of wheat. Note any flame, any sign of a gas forming, and any other action [1]. Put a lighted splint to the mouth of the tube [2] and continue to insert the splint at intervals as long as the action continues [3]. Note if the sodium entirely disappears [4].

3. Note the following properties of the liquid remaining in the test-tube: The taste (Technic 34), the touch when it is rubbed between the fingers, the effect on litmus (Technic 27), and the nature and the amount of residue left when a drop of the liquid is evaporated on a watch-glass [5].

4. Treat calcium the same way as the sodium was treated in 2 and 3 [6].

QUESTIONS: A. Are both the metals used in this Exercise elements? (See the list of elements on the inside of the back cover of this Manual.) B. Which metal shows the most vigorous action in the water? C. Is the gas that rises either oxygen or nitrogen? D. Did the gas come from the metal? (A). E. Might the gas have come from the water? F. Might it have been formed by the union of the metal with the water, or with some constituent of the water? G. Suggest any experiments that would decide which of these is the source of the gas.

EXERCISE 12

To collect and examine the gas formed when metals act on water and to examine further the other product formed

REQUIRED. Test-tube, evaporating dish, funnel, filter paper, lead foil, splints, rifle cartridge; calcium, sodium, slaked lime.

METHOD.

1. Place a test-tube full of water, mouth downward, in an evaporating dish of water. Drop a few shavings of calcium into the dish [1] and place the mouth of the test-tube over them so that the gas that rises will pass up into the test-tube. Collect a test-tube full of the gas.

2. Raise the test-tube full of the gas out of the water, and keeping the mouth down, bring a burning splint to the mouth of the test-tube [2].

3. The liquid has already been examined in Exercise 11 (4), but it should now be filtered (Technic 19) and the breath blown through the filtrate [3].

4. Dissolve some slaked lime in water, filter the liquid, and test the filtrate as the liquids in Exercise 11 were tested [4]; also blow the breath through the liquid [5]. Compare the results with those obtained from the liquid produced when calcium was placed in water [6] (Exercise 11, 3 and 4).

5. Some pupils may substitute sodium for calcium in the foregoing experiment. A piece of sodium the size of a grain of wheat is wrapped in lead foil and several holes are punched through the foil with a sharp lead-pencil, in order that the water may reach the sodium. The foil is then dropped into the water and an inverted test-tube filled with water is quickly brought over it [7]. Or the sodium may be packed in a small, empty rifle cartridge and the latter placed in the water, the open

end of the cartridge being brought up under the mouth of the test-tube full of water.

QUESTIONS: A. Considering all the experiments performed with water, which would you infer is the source of the hydrogen, (*a*) the metal or (*b*) the water (3). B. Do you think the liquid formed by dissolving calcium in water is lime-water? C. When the calcium is dissolved suggest a possible source of the particles that discolour the water? D. *It will not be necessary hereafter to state at the close of each exercise that a final paragraph should be written in your note-book.*

EXERCISE 13

To study the method of preparation and the properties of hydrogen

REQUIRED. Florence flask, pneumatic trough, thistle-tube, delivery-tube, rubber cork, test-tubes, gas bottles (one perfectly dry), splints, evaporating dish; granulated zinc, sulphuric acid.

CAUTION. *Never bring anything burning near a hydrogen generating apparatus.*

METHOD.

1. Arrange apparatus as in Figure 14 (Technic 22 and 38). The bottom of the thistle-tube must be below the level of the liquid in the flask. Slide a tea-spoonful of granulated zinc into the flask. Pour 25 c.c. (Technic 12) of water into a beaker, carefully add 5 or 6 c.c. of strong sulphuric acid, stir thoroughly, and allow to cool. Pour through the thistle-tube enough of the diluted acid to cover the zinc [1], and allowing the first part of the gas to escape, collect 1 bottle of hydrogen over water (Technic 14) to be used in 4.

2. Collect one test-tube of hydrogen and test its solubility in water [2] (Technic 17).

3. Collect two test-tubes of the gas, hold one with the mouth down, the other with the mouth up, for one-half minute, and test each with a burning splint [3].

4. Raise a bottle of the gas out of the water, and keeping the mouth down, bring a burning splint to the mouth of the bottle [4], insert it nearly to the bottom [5], then slowly withdraw it [6].

5. Now fill a perfectly dry bottle with the gas by downward displacement of the air (Technic 15) and ignite it, keeping the mouth of the bottle down [7]. Note as it burns any change on the inside of the bottle [8].

6. Half fill a test-tube over water with the gas; then, keeping the mouth downward, withdraw the test-tube from the water and allow the air to replace the remaining water in the test-tube. Place a burning splint to the mouth of the inverted test-tube [9].

7. When the generating flask has ceased giving off hydrogen, add more zinc until the evolution of gas ceases. Filter the contents of the flask into a beaker and evaporate the filtrate until half the water is gone, then let the beaker stand until the next day. If crystals have formed, pour off any liquid and note the shape of the crystals, and make a drawing of them [10]. If no crystals have yet formed, let the liquid evaporate further.

QUESTIONS: A. If the delivery-tube became stopped up, how could the stoppage be detected by watching the thistle-tube? B. What other method besides 3 could be used to prove that the gas is lighter than air? C. Explain why the splint went out when thrust into the jar, but rekindled while being withdrawn. D. How does the burning of pure hydrogen differ from that of a mixture of hydrogen and air? What is the cause of the explosion? E. What other substance besides hydrogen is formed when zinc and sulphuric acid react? (7). F. How would you explain the origin of the dark masses floating in the flask, which have to be filtered out before the liquid is put into the beaker to be evaporated (**Sec. 46**)? G. Make drawings of the apparatus, one showing the method of collection over water and another showing the method of collection by displacement of air.

CHAPTER V

SOLUTIONS

EXERCISE 14

Preliminary work (Technic 1)

(*a*) *Solubility of gases in liquids.*

When a pitcher of cold water is left in a warm place what collects on the outside of the pitcher?

Of what are the bubbles composed? Are they steam? Where did they come from?

Are there gases dissolved in water?

Where do fish obtain oxygen for respiration? Can you see the oxygen in the water,

When water is heated bubbles rise long before the water reaches the boiling point. Are these bubbles steam? If not, what are they?

Which dissolves more gas, hot or cold water?

When the cork is taken from a soda-water or ginger-ale bottle, of what do the bubbles that rise through the liquid consist?

Before the cork is removed is there any sign of these bubbles in the liquid?

Is it a change in the temperature of the liquid that causes the bubbles of gas to rise from a bottle of soda-water? If not, what is the change that causes the gas to come out of solution? Why are the bottles always

made of thick glass? What is the relation between the pressure of a gas and its solubility?

Read Technic 17 and explain why the solubiiity of gases in water can be tested in the way there indicated.

(*b*) *Solubility of liquids in liquids.*

State any pairs of liquids which, when thoroughly shaken together and allowed to stand (*a*) do, (*b*) do not separate into two layers? If two liquids completely mix is one soluble in the other? If the two form layers is that proof that one is quite insoluble in the other? How can you prove whether one liquid is quite insoluble in another or not?

(*c*) *Solubility of solids in liquids.*

If a small lump of sugar is dropped into a glass of water and the mixture is allowed to stand for some time, what happens to the lump? In time would the sweet taste appear in the upper portion of the liquid? If another lump of the same size were dropped into the water, would it disappear as rapidly as the first? If, as one lump disappears, another is dropped in, will there be a limit to the number that can be dissolved? After a state is finally reached in which no more sugar dissolves, no matter how long it remains in contact with the liquid, how could you cause more of the sugar to dissolve in the solution? Which dissolves more quickly in a glass of water, a lump of sugar or the same amount of powdered sugar? Why do we stir our tea? Name two methods by which dissolving can be hastened. How can you obtain salt or sugar from their aqueous solutions? Are the substances that make water turbid dissolved in it? How can such substances be separated from the water? If salt (soluble) and sulphur (insoluble) have been thoroughly shaken with water, how can you separate the salt and the sulphur from the water?

EXERCISE 15

To prepare a supersaturated solution

REQUIRED. Two test-tubes; sodium thiosulphate, sodium sulphate, washing-soda, blue vitriol.

METHOD.

1. Half fill a test-tube with sodium thiosulphate crystals. Add about 2 c.c. (Technic 12) of water and heat the mixture until the salt has completely dissolved [1]. Plug the test-tube with cotton wool, and with as little agitation of the solution as possible, cool it under the tap [2].

2. When the solution has become cool, note if it is quite clear and then drop in a crystal of the thiosulphate [3].

3. If time permits try by a similar method to form a supersaturated solution of sodium sulphate. For this purpose use crystals and do not warm the solution much beyond 30°C [4].

4. Repeat 1, except that a crystal of blue vitriol or washing-soda is dropped into the supersaturated solution [5].

5. Repeat 1, but instead of dropping a crystal of sodium thiosulphate into the solution, rub the point of a lead-pencil over a crystal of the salt and then dip it into the solution [6].

QUESTIONS: A. Can a supersaturated solution be distinguished by its appearance from a saturated or from an unsaturated solution? B. How can a supersaturated solution be distinguished from such solutions? C. If a crystal of the solute is dropped into unsaturated, saturated, and supersaturated solutions, how will each solution affect the crystal? D. Is it correct to say that a saturated solution has as much of the solute dissolved in it as it can hold at that temperature? E. Will a crystal of a salt other than the solute act as does a crystal of the solute (4)? F. Will a minute piece of the solute cause precipitation (5)?

EXERCISE 16

To study some properties of hydrates

REQUIRED. A hard-glass test-tube, test-tube, beaker, elbow tube, rubber connector, straight glass tube; (1) blue vitriol, (2) gypsum, (3) Epsom salts, (4) alum, (5) common salt, (6) potassium chlorate, (7) saltpetre, (8) calcium carbonate, sodium, anhydrous copper sulphate.

METHOD.

1. Let each pupil test one of the first four numbered substances and one of the last four numbered substances. Arrange the apparatus as in Figure 16. Into the hard-glass test-tube place enough of the powdered salt to occupy 7 c.c. (Technic 12); have the mouth of the tube slightly lower than the base. The beaker contains cold water.

Heat the salt gently, then more strongly, but never strongly enough to melt it [1]. Continue the heating as long as there is any action. Note any change in the salt [2].

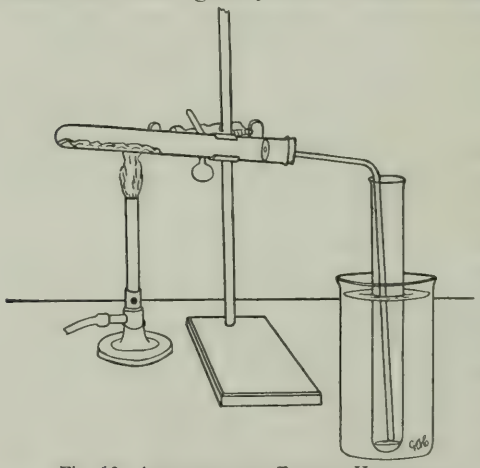


Fig. 16—APPARATUS FOR TESTING HYDRATES

2. Note any properties of the condensed liquid in the test-tube [3]. Test the liquid with a very small piece of sodium (Technic 4), and with a small piece of anhydrous copper sulphate [4].

3. Make a drawing of the apparatus.

QUESTIONS: A. Classify the salts into two groups. B. What name is given to those from which water passes off when they are heated (**Sec. 64**)? C. Are these salts changed by the loss of water? D. Are they, after being heated, different substances from what they were before? E. Does the driving off of the water produce a chemical change (**Sec. 29**)? F. The water obtained from these salts is called "water of crystallization". Do the salts that give off no water when heated crystallize as well as those that do? G. Hence criticise the term "water of crystallization".

EXERCISE 17

To study the effect of exposing certain salts to moist air

REQUIRED. Watch-glasses; anhydrous copper sulphate, magnesium chloride, washing-soda crystals, sodium sulphate crystals, calcium chloride for drying, potassium hydroxide, zinc chloride, blue vitriol, saltpetre, potassium chloride, and marble.

METHOD.

1. Divide the substances mentioned above among the class, each pupil testing at least two, and each pupil recording the results for all of the substances. On a watch-glass place a lump of the substance selected as large as a marble, and at once weigh the watch-glass with its contents [1]; note also the appearance of the substance [2].

2. Allow the substance to remain exposed to the air for twenty-four hours, then note any change in its appearance [3], and weigh it again [4].

QUESTIONS: A. Which substances increase in weight? Which decrease in weight? Which remain the same in weight? B. Since any loss or gain in weight is due to loss or gain of water, classify the above substances as efflorescent or deliquescent (**Secs. 63, 64**).

CHAPTER VI

THE LAWS OF COMBINATION

EXERCISE 18

To find the combining weight of mercury and of magnesium

REQUIRED. Hard-glass test-tube, crucible and cover, retort stand, clay triangle, blast lamp, emery-paper; mercury oxide, magnesium ribbon.

METHOD. (*a*) *Mercury.*

1. Weight a clean, dry, hard-glass test-tube [1].

2. Place in the bottom of this tube (Technic 26) about 1 gram of mercury oxide and weigh the tube and contents [2].

3. Heat the oxide as long as a glowing splint is rekindled, being careful to lose no mercury. Cool the residue and weigh the test-tube and contents again [3] (Technic 39).

4. Empty the mercury from the test-tube into the bottle labelled "impure mercury" (Technic 30).

(*b*) *Magnesium.*

1. Clean with emery-paper a piece of magnesium ribbon about six inches long, cut it into short pieces, place them in the crucible, cover with the lid, and weigh the crucible and contents [4].

2. Heat the crucible very strongly, keeping the lid on it; as the magnesium burns raise the lid slightly to admit air, but do not allow any smoke to escape; repeat the

raising of the lid at intervals of a minute until the magnesium ceases to glow when the lid is raised; then remove the lid and heat the crucible intensely (blast lamp) for five minutes; cool, and then weigh the crucible, lid, and contents [5].

3. With hot nitric acid clean the white residue from the crucible, but do not try to scrape off the black stain, as it will not injure the crucible for experimental purposes.

QUESTIONS: A. Calculate from your experimental data what weight of mercury reacts with 8 grams of oxygen; also what weight of mercury oxide produces 8 grams of oxygen. B. Hence, what is a combining weight (**Sec. 68**) of mercury? What is a combining weight of mercury oxide? C. Calculate from the experimental data a combining weight of magnesium and of magnesium oxide.

CHAPTER VII.

THE SHORTHAND OF CHEMISTRY

EXERCISE 19

To find the formula of an oxide of tin

REQUIRED. Crucible, retort stand, clay triangle; granulated tin, chemically pure nitric acid.

METHOD.

1. Weight a clean, dry crucible [1].

2. Put about one gram of granulated tin into the crucible and weigh the crucible and tin [2].

3. Pour about 5 c.c. (Technic 12) of chemically pure nitric acid on the tin, a little at a time, until all the tin is dissolved [3]. If the action is slow, slightly heat the crucible, working near the hood throughout the experiment (Technic 9).

4. By heating the crucible drive off all excess of nitric acid, but be careful not to allow the liquid to boil over; when the residue thickens, as it is likely to spurt out, heat it very carefully (patience!). Spurting can be avoided by holding the burner in the hand and touching the flame to the bottom of the crucible every few seconds until the residue is dry. After the residue is dry, heat it intensely (blast flame) for fifteen minutes, then cool, and weigh again [4] (Technic 39). The substance left is an oxide of tin.

5. Tabulate your observations as follows:

Weight of empty crucible	—grams (1)
Weight of crucible+tin	—grams (2)
Weight of crucible+oxide of tin	—grams (3)
Weight of tin (2)—(1)	—grams (4)
Weight of tin oxide (3)—(1)	—grams (5)
Weight of oxygen (5)—(4)	—grams (6)

QUESTIONS: A. What are the atomic weights of tin and of oxygen (See the table on the inside of the back cover of this Manual)? B. From (5) and (6) find how many grams of oxygen unite with 119 grams (an atomic weight) of tin. C. How many atomic weights of oxygen are obtained in B? (If the experiment is performed with care an exact number of atomic weights will be obtained.) D. In this oxide how many atomic weights of oxygen are combined with one atomic weight of tin? E. Write the simplest formula that expresses the composition. F. In your final paragraph state all the data it is necessary to know in order to calculate the molecular formula of a substance, and also state how each datum is obtained (**Sec. 76**).

CHAPTER VIII

COMMON SALT AND ITS DERIVATIVES

EXERCISE 20

To study some properties of common salt.

REQUIRED. Bunsen burner, test-tubes, glass rod, watch-glass; common salt, sulphuric acid, phosphoric acid, silver nitrate solution, ammonium hydroxide solution, litmus paper.

METHOD.

1. Find if common salt is soluble in water [1] (Technic 16).

2. Make a saturated solution of common salt in a test-tube by shaking the powdered salt with distilled water for several minutes, filter a little of the solution into a watch-glass, and allow it to stand in the watch-glass until the water evaporates. Note with the aid of a magnifying glass the shape of the crystals and make drawings of two or three of them [2].

3. Note the colour which common salt imparts to the flame [3] (Technic 24).

4. To 2 c.c. of a dilute solution of common salt add silver nitrate solution, a drop at a time [4], as long as a precipitate is produced; when the precipitate settles, pour off the liquid and divide the precipitate into two parts; to one part add 2 or 3 c.c. of nitric acid and boil

the mixture [5], to the other part add 5 c.c. of ammonium hydroxide solution and, if necessary to produce a change, shake the mixture [6].

5. Put as much common salt as would lie on a ten-cent piece into each of two test-tubes. To the first add a few drops of concentrated sulphuric acid [7], and to the second add a few drops of strong phosphoric acid [8]; heat in each case [9], if necessary, and test the gas coming off each test-tube as follows: (*a*) Blow the breath across the mouth of the test-tube, (*b*) bring moist litmus paper to the mouth of the tube, (*c*) bring a rod previously dipped into ammonium hydroxide solution near the mouth of the tube, (*d*) smell cautiously the gas (Technic 33), (*e*) bring a glass rod, previously dipped into water, into the mouth of the test-tube and then taste (Technic 34) the liquid on the rod [10].

QUESTIONS: A. Write in your Note-book all the properties of common salt determined in this exercise as well as the colour, taste, etc., that can be easily detected. B. Do sulphuric and phosphoric acids, when they react on common salt, produce the same gas? C. What are some properties of the gas formed by acting on common salt with sulphuric or phosphoric acid? Do you think it could be collected over water? (5, *e*). D. Which is the better acid to use in generating it, sulphuric or phosphoric? Why?

EXERCISE 21

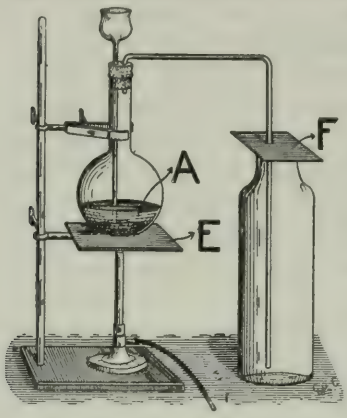
To study the properties of hydrogen chloride

REQUIRED. Florence flask, thistle-tube, two-holed rubber cork to fit the flask, two elbow-tubes, one with one arm 8 inches long, 2 dry gas bottles, test-tubes, a large test-tube, deflagrating spoon, asbestos paper, asbestos pad, splints; common salt, concentrated sulphuric acid, hydrochloric acid, litmus paper, zinc, marble, nitric acid, ammounium hydroxide solution, silver nitrate solution.

CAUTION. *Since great care must be taken to prevent the gas from escaping into the room, the experiment should be performed close to the hoods.*

METHOD.

1. Fit up apparatus as in Figure 17. Place two teaspoonfuls of common salt in the flask, add enough water to moisten the salt, and add through the thistle-tube enough concentrated sulphuric acid to cover the salt [1]. The flask should be set in a vessel of water, and the water should be heated, but if such a vessel is not available, place the flask on an asbestos pad and heat the mixture very gently [2]. Collect two bottles and one test-tube full of gas. During the collection, keep the mouths of the vessels up (Technic 15) and test with moist litmus paper to find when they are full. See that all the containers of the gas are perfectly dry. Each bottle and test-tube, as soon as it is filled, should be used in the way indicated below. After the vessels are filled with the gas, insert the end of the delivery tube into a large test-tube one-quarter filled with water. Have the end of the delivery tube as close as possible to the surface of the water without touching it. Allow the gas to pass into this test-tube until the generator is exhausted. Retain the liquid in the large test-tube for 5, which may be performed at a succeeding lesson.



F 17—APPARATUS FOR PREPRATION OF HYDROGEN CHLORIDE

A. Common salt and sulphuric acid. E. Asbestos sheet. F. Cardboard, covering bottle in which gas is collected.

2. Put your finger tightly over a test-tube of the gas and thrust the mouth of the test-tube under water before withdrawing the finger [3].

3. Insert a burning splint into a bottle of the gas [4].

4. Place a clean piece of sodium (Technic 4) as large as a grain of wheat on a piece of asbestos paper lining a deflagrating spoon, ignite the sodium in a flame, and then quickly insert it into a bottle of the gas [5]. Taste the residue left in the spoon [6], being careful that no unburnt sodium that might remain is taken into the mouth.

5. Divide the solution of the gas in water into four parts. Test the first with litmus [7]; into the second drop some zinc dust [8], and test the gas that comes off with a burning match [9]; to the third add a small lump of marble [10], and test any gas produced by placing the end of a glass rod that has been dipped into lime-water at the mouth of the tube [11]; treat the fourth solution exactly as the common salt solution was treated in Exercise 20, 4 [12].

6. Treat hydrochloric acid taken from a reagent bottle in the same way as the solution in 5 was treated [13].

Questions: A. Make a sketch of the apparatus. B. Why was the delivery tube in 1 not inserted into the water? C. What constituent of common salt can be identified from 4? D. Write in your Note-book all the properties of the gas and of its aqueous solution to be observed in this and the preceding experiment. E. Is the solution the same substance as the liquid in the laboratory labelled hydrochloric acid? F. Does silver nitrate act in the same way with a solution of common salt as with a solution of hydrochloric acid? G. How could these two solutions be distinguished?

EXERCISE 22

To study the properties of chlorine

REQUIRED. Apparatus similar to that used for preparing hydrogen chloride (Exercise 21, Fig. 17), deflagrating spoon, 6 gas bottles, large test-tubes, corks to fit gas bottles, asbestos paper, filter paper; manganese dioxide, hydrochloric acid, sulphuric acid, turkey-red cloth, coloured flowers, green leaves, powdered antimony, sodium, turpentine, vaseline.

CAUTION. *All experiments with chlorine should be performed close to the hood; care should be taken not to inhale the gas.*

METHOD.

1. Fit up apparatus like that illustrated in Figure 17. Put two tea-spoonfuls of manganese dioxide into the flask, then add enough strong hydrochloric acid to cover the powder [1]. If possible set the flask in a vessel of water and warm the water, or at any rate warm the flask very gently [2]; collect 6 bottles of the gas by displacement of air, keeping the mouths of the bottles up (Technic 15). If white paper is held behind the bottle, the colour of the gas will indicate when the bottle is full. As soon as either a bottle or test-tube is full, close it tightly with a cork, the bottom of which is covered with vaseline. One of the bottles in which the gas is to be collected should have half an inch of concentrated sulphuric acid in the bottom of it.

2. Into the bottle containing sulphuric acid put a small piece of perfectly dry turkey-red cotton cloth, not allowing the cloth to touch the acid, and insert the cork so as to catch the cloth between it and the neck of the bottle. Into another bottle drop a piece of the same cloth, a postage stamp with a postmark on it, and a

piece of white paper with printing, lead-pencil marks, and ink marks on it, all of the articles being wetted before being placed in the bottle. In half an hour note the changes in the articles in both bottles [3].

3. Into a third bottle sprinkle a few pinches of antimony powdered very fine [4].

4. Into a fourth bottle put a small piece of yellow phosphorus (Technic 3) on a deflagrating spoon lined with asbestos paper [5]. Do not ignite the phosphorus before putting it into the bottle.

5. Into a fifth bottle drop a small, thin piece of sodium pressed flat [6]; cork the bottle, and leave it until the next day, then note the taste and colour of the substance produced by the sodium [7]. Test this substance to find if it is common salt [8] (Exercise 20, 4).

6. Into a sixth bottle insert a piece of filter paper soaked in warm turpentine [9] (Technic 9).

7. Pass chlorine for some time into 20 c.c. of water. Divide the solution into two parts; into one drop litmus paper, paper with ink-marks on it, and coloured cotton cloth; let these substances remain for some time in the solution of chlorine [10]. Cork the test-tube containing the rest of the solution, place it in direct sunlight [11], and leave it until the next day [12]; then test a part of the liquid with litmus, ink marks, and coloured cloth [13], and test the remainder as is Exercise 21, 5 [14].

QUESTIONS: A. Make a drawing of the apparatus for preparing this gas. B. If the flask were heated strongly, what other substance would be mixed with the chlorine that comes off? C. What other substance must be present in order that chlorine can bleach? (2). D. With what substance would you infer chlorine does not readily unite? (6). E. With the help of your answer to D, explain why printing and lead-pencil marks were not bleached. F. What gas would you suppose was formed when chlorine water was exposed to sunlight? G. Write equations for 1 (**Sec. 107**), 3, 4, 5, 6, (**Sec. 109**), 7, (**Sec. 110**).

EXERCISE 23

To study the action of chloride of lime (bleaching powder)

REQUIRED. Test-tubes, turkey-red cloth; chloride of lime, sulphuric acid.

METHOD.

1. To a little chloride of lime add an acid [1], gently heat the mixture [2], and note the colour and odour of the gas that comes off [3].

2. Make a thin paste of chloride of lime and nearly fill each of two test-tubes with the paste and put a dilute solution of sulphuric acid (1 of acid to 25 of water) in another. Immerse one piece of coloured cloth in the acid and then put it in the paste in one test-tube and put another piece of the same cloth in the other test-tube of paste without immersing it in the acid. Note which piece of cloth is bleached first [4].

CHAPTER IX.

CARBON AND ITS COMPOUNDS

EXERCISE 24

Preliminary Work (Technic 1)

State some properties of charcoal.

When wood burns, under what conditions will lumps of charcoal be left in the ashes?

Does wood, in burning, always produce charcoal?

Does wood, in burning, always leave ashes?

Would you expect charcoal to leave ashes when it burns? Why?

Do you think the charcoal or the wood from which it is obtained would weigh more? Give reasons for your answer.

What happens to wood left for a considerable time in a hot oven? Does the wood burn? In such circumstances what evidence have you that other substances besides charcoal are produced from the wood?

If sugar is left on a hot stove what product is finally formed? Name any other substances that act similarly to sugar in this respect. Does bread? Does meat? Do potatoes? Name substances that never char no matter how strongly they are heated.

Under what conditions does a lamp burn with a smoky flame?

Does the soot deposited from a smoky lamp in any way resemble charcoal?

What other substances, besides the kerosene in a lamp, in burning, produce lampblack?

EXERCISE 25

To study the properties of charcoal

REQUIRED. Test-tubes, hat pin, funnel, filter paper, crucible and lid, mortar and pestle, retort stand and ring, clay triangle, deflagrating spoon, gas bottle. Bunsen burner, glass rod; wood charcoal, litmus, indigo, carmine, and other coloured solutions, red lead, lime-water.

METHOD.

1. Drop a piece of charcoal on water and note how high out of the water it floats [1]. By means of a hat pin thrust the charcoal under the water, and while it is immersed, boil the water [2]. Continue the boiling as long as bubbles rise from the charcoal. Then loose it from the hat pin, and note whether it floats or not [3].

2. Grind some charcoal, preferably bone-black, nearly fill a crucible with it, place the lid on the crucible, and heat it strongly for ten minutes. While this is proceeding prepare the materials for 4, 5, and 6 of this experiment. Set aside half of the heated charcoal for 4. Put the remainder into a test-tube (Technic 26). Into this test-tube and also into another one pour about one half a cubic centimetre of ammonia solution. Shake the one containing charcoal from time to time, and every few minutes until the end of the class period smell (Technic 33) each test-tube [4].

3. Let different members of the class use 5 c.c. of differently coloured liquids, such as indigo, carmine, log-

wood, litmus, potassium permanganate, red ink, etc. In each case pour the coloured liquid into a test-tube, add the charcoal retained from 3, heat the mixture, and filter it [5].

4. Heat strongly in a crucible a lump of charcoal as large as a pea [6]. Continue heating until all action ceases. Note if anything is left in the crucible and record the easily observable properties of any such residue [7].

5. Pour half an inch of lime-water (**Sec. 122**) into a gas bottle and shake the liquid around in the bottle. Now ignite a piece of charcoal on a deflagrating spoon, insert the spoon almost to the bottom of the bottle, and withdraw it only when the charcoal has become extinguished. Now shake the lime-water around in the bottle again [8].

6. Mix together in a crucible as much red lead as will lie on a twenty-five-cent piece and half as much finely powdered charcoal, place the lid loosely on the crucible, and heat the crucible and contents as strongly as possible for fifteen or twenty minutes. From time to time bring a glass rod dipped in clear lime-water near the mouth of the crucible and note if the gas coming off causes the lime-water to turn milky [9]. Turn out the contents of the crucible on mica and note if there is any metal present [10].

QUESTIONS: A. Why does the charcoal float so lightly on water before it has been boiled and sink after it has boiled? B. What structural character of charcoal does this phenomenon indicate? C. Read how charcoal is formed (**Sec. 118**), and remembering the cellular structure of wood, explain its porosity. D. What becomes of the colouring matter in the liquids? (3). E. Read your text-book (**Sec. 118**) and find what use of charcoal depends on this property. F. What is formed when charcoal burns in air (**Sec. 120**)? G. Is there any ash? H. Write the equation expressing the reaction when charcoal

burns in air; consider the charcoal to be pure carbon. I. What is the gas formed when red lead and charcoal are heated together? J. Write the equation expressing the probable reaction. K. Find from the text-book (**Sec. 48**) the meaning of reducing substance and of oxidizing substance, and judged from this reaction, state to which classes red lead and charcoal belong.

EXERCISE 26

To study some properties of the gas formed by burning charcoal in air or oxygen

REQUIRED. Three gas bottles, cork for each bottle, apparatus for making oxygen from potassium chlorate and manganese dioxide (Exercise 6), deflagrating spoon, splint, asbestos paper; litmus, sulphur, magnesium ribbon, charcoal.

METHOD.

1. Prepare and collect over water three gas bottles full of oxygen. Burn charcoal on a deflagrating spoon in each bottle, moving the spoon up and down until it is extinguished, then cork the bottles tightly for use in 2, 3, 4, and 5.

2. Add 10 c.c. of lime-water to the first bottle and shake it [1].

3. Keeping a cork in the mouth of the bottle so that none of the gas can escape, test the gas in the second bottle with moist litmus paper [2] (Technic 27).

4. Insert a burning splint into the third bottle [3]. Insert burning sulphur into the same bottle. Make a spiral by winding some magnesium ribbon loosely around a lead-pencil, withdraw it from the pencil, suspend it from the bottom of the deflagrating spoon by one end, ignite the other end, and insert it carefully but quickly

into the same bottle [4]. Note the two substances in the ash [5], test the black one for charcoal [6] (Exercise 25).

QUESTIONS: A. Write equations for the reactions occurring in 1, 2, (**Sec. 122**), and 4. B. What acid is formed in 3 (**Sec. 122**)?

EXERCISE 27

To study other methods of producing carbon dioxide

REQUIRED. Test-tubes, one-holed rubber cork to fit the test-tube, elbow tubes, beaker, watch-glass, glass rod, Bunsen burner, candle, alcohol lamp, kerosene lamp, beaker; lime-water, yeast, syrup, sodium carbonate, magnesium carbonate, sodium bicarbonate, calcium carbonate, various acids.

METHOD.

1. Allow a watch-glass with some lime-water in it to remain on the bench for an hour or longer; note any sign of a film on its surface [1].

2. Blow the breath through a glass tube into lime-water in a test-tube [2].

3. Into each of three test-tubes put a few lumps of a carbonate, different pupils using different carbonates. Select any three acids with which the laboratory is supplied and pour the solutions of the acids into the test-tubes containing the carbonate, one acid being added to each test-tube [3]. Bring a glass rod dipped in lime-water to the mouth of each test-tube to test if carbon dioxide is evolved [4]. Note which acid generates the gas most freely [5].

4. Half fill a test-tube with a solution of syrup, add a little yeast to the test-tube, insert a rubber cork with an elbow tube to which a delivery tube is attached and lead the delivery tube into a test-tube (Technic 35) containing an inch of lime-water. Allow the sugar

solution to stand near a warm radiator or stove for a few days. Note any change in the sugar and in the lime-water [6].

5. Burn different substances such as a candle, alcohol lamp, kerosene lamp, wood, etc.; hold over the flame produced by each an inverted beaker wetted on the inside with lime-water [7].

QUESTIONS: A. From a study of 1, 2, and 5, how would you account for the origin of some of the carbon dioxide in the air? In what districts would you expect to find the carbon dioxide in the largest quantities? B. Which is the cheapest carbonate to use for making carbon dioxide (Appendix I)? C. From 4 show the part played by yeast in the rising of bread.

EXERCISE 28

To study the properties of acetylene

REQUIRED. Large test-tube, pointed glass tube, duster, beaker, one-holed rubber cork, gas bottles, funnel, splint, evaporating dish, filter paper, pneumatic trough; calcium carbide, litmus, lime-water.

METHOD.

1. Fill several gas bottles with water and invert them in a pneumatic trough containing water. Drop a few lumps of calcium carbide into the water [1], bring the mouth of one of the bottles over the carbide, and collect a bottleful of the gas produced [2].

2. By lifting a bottle of the gas from the water and bringing a burning splint to the mouth of the bottle, note the colour, odour, and inflammability of the gas [3] (hood).

3. Find in what proportions the gas must be mixed with air in order that it may burn without producing any soot [4]. To accomplish this, allow the inverted

bottle to become only half-filled with the gas, then raise the bottle from the water, and the air will replace the other half of the water; at once bring a lighted splint to the mouth of the bottle (hood). Clean the bottle after each trial. Repeat the experiment, filling successively one quarter, one eighth, etc., of the bottle with the gas till it burns without producing any soot.

4. Pour 10 c.c. (Technic 12) of water into a large test-tube, fit a pointed glass tube (Technic 37) into a one-holed rubber cork, drop several lumps of carbide into the water, insert the cork tightly, wrap a duster around the test-tube as a precautionary measure, and after the gas has been coming off (hood) for at least *two minutes,* light the jet [5]; note the colour of the flame [6]; hold a cold, dry beaker over it for a moment [7], then hold over it a beaker the inside of which is wetted with lime-water [8]. Use the substance left in the test-tube for 5.

5. After all action ceases in the large test-tube used in 4, filter the solution and divide the filtrate into three parts. Evaporate the first on a water-bath [9] (Technic 21), test the second with litmus [10], and blow the breath through a tube into the third [11].

QUESTIONS: A. From 3 and 4 what two elements are contained in the gas? B. From 5 what other product besides the gas would you infer is formed when water acts on calcium carbide? C. Considering these the only two products, write the equation, finding in the text (**Sec. 131**) the formulæ of calcium carbide and acetylene. D. If the equation in C represents the reaction, what would you conclude to be the nature of the insoluble material left on the filter-paper in 5? E. Read in the text-book (**Sec. 225**) how calcium carbide is formed and decide what the impurities are likely to be. F. How can you fit up an acetylene generator that gives a steady stream of the gas from a jet? If the teacher approves of your method and time permits set up such a generator.

CHAPTER X

CARBONATES IN THE HOUSEHOLD

EXERCISE 29

To study the composition of plain soda-water

REQUIRED. Bottle of soda-water, large test-tube, test-tubes, one-holed rubber cork, delivery tube; lime-water, litmus.

METHOD.

1. Pour about 10 c.c. (Technic 12) of the soda-water into each of two test-tubes and half fill a large test-tube with the same liquid.

2. Test with the litmus the contents of the first test-tube [1].

3. Add the contents of the test-tube used in 2 to 10 c.c. of lime-water in a test-tube [2].

4. Add the contents of the second test-tube to 2 c.c. of lime-water that has been made milky by blowing the breath through it, and shake the mixture [3].

5. Insert the one-holed rubber cork into the large test-tube, attach to the test-tube a delivery tube, boil the soda-water in the tube [4], and pass the gas that comes off through lime-water [5] (Technic 35). Continue the boiling until no more gas comes off. Cool the liquid, note its taste [6], and test it as the soda-water was tested in 2, 3, and 4 [7].

QUESTIONS: A. What acid is contained in the soda-water (**Sec. 135**)? B. What is the white precipitate in 3? Write the equation for 3. C. Explain the disappearance of the white precipitate in 4 (**Sec. 138**). D. What kind of water dissolves limestone rocks? E. Can all the carbon dioxide be driven out of its aqueous solution by boiling? (5).

EXERCISE 30

To study the action of soap on hard and on soft water

REQUIRED. Test-tubes; Castile soap, salts of calcium, magnesium, sodium, potassium, washing-soda.

METHOD.

1. Prepare a test-tube of soap solution by shaking a few small shavings of good Castile soap with 20 c.c. (Technic 12) of distilled or rain water. Filter the solution.

2. Into each of four test-tubes pour 10 c.c. of distilled water; to the first add *pure* sodium chloride, to the second potassium chloride, to the third calcium chloride, and to the fourth magnesium chloride. In each case use a quantity of salt not larger than the head of a pin and shake the mixture until the salt is dissolved. Note whether the liquid in each test-tube feels smooth or rough [1].

3. To each test-tube in 2 add two drops (Technic 13) of soap solution and shake the mixture [2]; if no permanent lather forms add two more drops and shake; repeat this operation until a lather that does not disappear in two minutes is formed, and note how many drops of soap each requires [3].

4. Prepare four more test-tubes containing similar solutions of salts to those in 3. Add to each a lump

of washing-soda as large as a grain of wheat [4]. Note if the liquid feels rough or smooth and then treat it with a soap solution as was done in 3 [5].

QUESTIONS: A. Which solutions feel rough and which smooth? B. Which solutions give a precipitate with soap solution? C. Explain why those that give a precipitate require more soap to produce a lather than the others. D. With which solutions does washing-soda give a precipitate? E. Write the equations expressing the reactions in the cases where precipitates are formed by adding washing-soda in 4 and suggest why washing-soda softens these waters.

EXERCISE 31

To examine the temporary hardness in water

REQUIRED. Test-tubes, apparatus to generate carbon dioxide, Bunsen burner; lime-water, soap solution.

METHOD.

1. Half fill a test-tube with lime-water, dilute it with half as much distilled water, and pass in carbon dioxide until two successive changes take place in the liquid [1].

2. Divide the cleared lime-water into two parts; test the first with soap as in Exercise 30, 3 [2], boil the second [3], filter, and test it with soap in the same way [4].

QUESTIONS: A. Compare the result of 1 with the results obtained in Exercise 29, 4. Explain the result in 1 (**Sec. 122**). B. Refer to Exercise 29, 5, and by the aid of it explain why calcium carbonate is precipitated when the solution in 2 is boiled. C. Explain the formation of the deposit of limestone (so-called lime) in the bottom of a kettle.

EXERCISE 32

To study the action of baking-soda and baking-powder

REQUIRED. Large test-tube, one-holed rubber cork with delivery tube, Florence flask, thistle-tube, two-holed rubber cork, Bunsen burner; baking-soda, cream of tartar, alum, baking-powder.

METHOD.

1. Place 5 c.c. of baking-soda in a large test-tube, moisten it with water, insert a rubber cork and delivery tube, heat the soda [1], and pass the gas that comes off into lime-water [2].

2. Make a solution of baking-soda in a Florence flask fitted with a rubber cork, thistle-tube, and delivery tube as in Figure 17, through the thistle-tube add a strong solution of cream of tartar [3], heat the liquid [4], and instead of collecting the gas in a jar, pass it through lime-water [5].

3. Repeat 2 substituting alum for cream of tartar [6].

4. Repeat 2 substituting any brand of baking-powder for baking-soda and instead of a solution of cream of tartar, pour pure water through the thistle-tube [7].

QUESTIONS: A. What gas is produced in all the above reactions? B. If baking-soda or baking-powder, which is a mixture of baking-soda and cream of tartar or alum, is mixed with dough and heated, explain why the dough rises. C. Explain why dough after it has risen, if placed in a cool place, will fall. D. Why does the pastry not fall after it is cooked? E. Which acts more rapidly, the baking-soda (1) or the baking-powder (4)?

CHAPTER XI.

SULPHUR AND ITS COMPOUNDS

EXERCISE 33

To study some properties of sulphur

REQUIRED. Test-tube, mortar and pestle; fine copper wire, silver coin, roll sulphur, flowers of sulphur, alcohol, ether, carbon bisulphide, mercury.

METHOD.

1. Test the solubility of sulphur in water, alcohol, and carbon bisulphide [1] (Technic 16); work at the hood with the latter substance and see that all flames on the bench are extinguished.

2. Note the properties of roll sulphur such as colour, brittleness, hardness, etc. [2].

3. Ignite a piece of sulphur and note the odour of the gas produced, the colour of the flame, and the colour of the burning sulphur [3].

4. Place some moist, powdered sulphur on a silver coin and leave it there until the next lesson, then wash off the sulphur and note the colour of the silver [4].

5. Grind together in a mortar a drop of mercury and some flowers of sulphur [5].

6. Heat a little roll sulphur in a test-tube until it boils vigorously; when the test-tube is filled with

sulphur vapour, insert into the tube a spiral of very fine copper wire or a very thin sheet of copper foil [6]. Withdraw the wire, examine it, and note if it is still copper [7].

QUESTIONS: A. State with what elements sulphur unites in 3, 4, 5, and 6. B. Write equations for reactions 3, 4, 5, and 6 (**Sec. 150**).

EXERCISE 34

To study the modifications of sulphur

REQUIRED. Test-tubes, evaporating dish, Bunsen burner, funnel, watch-glass, beaker, filter paper; roll sulphur, carbon bisulphide.

METHOD.

1. Saturate with roll sulphur 10 c.c. (Technic 12) of carbon bisulphide. Decant the clear liquid into an evaporating dish, cover the latter with a watch-glass, and place it in the hood until the liquid has evaporated. Note the shape, colour, and transparency of the crystals [1]. Make drawings of several crystals [2]. Examine the crystals after several days and note if they have changed [3]. (The teacher may prepare these crystals before the class period.)

2. Two-thirds fill a test-tube with roll sulphur, and holding the test-tube well above a flame, warm it very gradually (great patience!) until the sulphur melts to a straw-coloured liquid [4]; if the liquid during the heating has turned dark brown, the experiment must be repeated. Pour the straw-coloured liquid into a filter paper in a funnel. Watch the solidification of the sulphur, and when a crystal at the surface extends from the edge to the centre, pour the liquid remaining into a beaker of water. Unfold the paper at once and note the shape, colour, transparency, and lustre of the crystals

[5]. Make drawings of several of them [6]. Place several of the crystals in a crucible, cover it, and weigh the crucible and contents [7]. Allow the crystals to stand for several days, then note any change in the appearance of the crystals [8]; weigh the crucible and content again [9].

3. Note the colour, hardness, and solubility in carbon bisulphide of the melt poured into the water in 2 [10].

4. Half fill the test-tube used in 2 with roll sulphur, heat as in 2 until liquefied, then heat the liquid slowly until it boils; as its temperature is being raised, note any changes in colour and viscosity of the liquid [11]; the latter property can be determined by occasionally shaking the liquid. Look down the test-tube while it is boiling and note the colour of the vapour [12].

5. Pour the boiling liquid in 4 into a beaker of water and note the colour, consistency, and solubility in carbon bisulphide of the melt poured into the water [13]. The test-tube in which the sulphur was heated cannot be cleaned readily.

QUESTIONS: A. What are the modifications of solid sulphur (1, 2)? B. Which are formed at the higher temperature, the crystals in 1 or in 2? C. At about what temperature were the crystals in 2 formed (**Sec. 149**)? D. Did the crystals in 2 change in appearance when left for several days at room temperature? E. Were they converted into a new substance (**Sec. 119**)? F. Did they change in weight? G. What name is given to two forms of an element, one of which is converted into the other without change of weight (**Sec. 119**)? H. Did the sulphur poured into water in 2 and 5 harden in both cases at about the same temperature? I. How would you account for the difference in behaviour in the two cases? J. Has the plastic mass in 5 properties different from ordinary sulphur?

EXERCISE 35

To study the properties of hydrogen sulphide

REQUIRED. Florence flask, 3 gas bottles, apparatus and reagents for generating chlorine (Exercise 22), splints, beaker, funnel, filter paper, thistle-tube, elbow tube, rubber delivery tube, two-holed rubber cork; granulated ferrous sulphide, sulphuric acid, litmus paper, nitric acid, ammonium hydroxide, solutions of copper sulphate, lead nitrate, stannous chloride, silver nitrate, silver coin.

METHOD.

1. Fit up apparatus as in Figure 17. Into the Florence flask slide a large spoonful of granulated ferrous sulphide, insert the cork, cover the sulphide with water, pour in a little sulphuric acid, and heat the flask gently if necessary, in order to make the gas come off freely [1]. Collect three bottles of the gas by displacing air (Technic 15), keeping the mouth of the gas bottle up. A piece of paper dipped in lead nitrate solution and held near the mouth of the bottle turns dark when the bottle is full. Cork the bottles for use in 5, 6, and 7.

2. Saturate a bottle of water with the gas (Technic 18) and use the solution for 3 and 4.

3. Add some of the solution of the gas to solutions of silver nitrate, copper sulphate, stannous chloride, and lead nitrate [2].

4. Set aside half a test-tube of the solution, which must be perfectly clear. At the end of three days shake up the liquid and note any deposit [3]. Note the effect of the liquid remaining on lead nitrate paper [4] (**Sec 157**).

5. Set a bottle of the gas on the bench and lower a blazing splint slowly into the bottle [5]. Note the odour of the vapour produced by combustion and any deposit on the inside of the bottle [6].

6. Note the effect of the gas on moist litmus and on a silver coin [7].

7. Write equations for 1, 3, 4, 5 (**Secs. 157, 158**).

QUESTIONS: A. In preparing this gas could other metallic sulphides besides ferrous sulphide be used? B. Could hydrochloric acid be used instead of sulphuric acid? C. Which would probably produce the purer gas, sulphuric or hydrochloric acid? Why? D. Give a reason why you think part of the sulphur in 5 burned. E. Why was part of the sulphur deposited on the inside of the bottle? F. Why could you infer from 4 that this gas is a reducing agent. (**Sec. 157**)?

EXERCISE 36

To study the properties of sulphur dioxide

REQUIRED. Florence flask, separating funnel (Technic 8), tube, bent as in figure, 2 gas bottles, splints, test-tubes, apparatus for generating hydrogen sulphide (Exercise 35); sodium bisulphite, concentrated sulphuric acid, potassium permanganate, coloured flowers or the red skin of an apple, litmus paper.

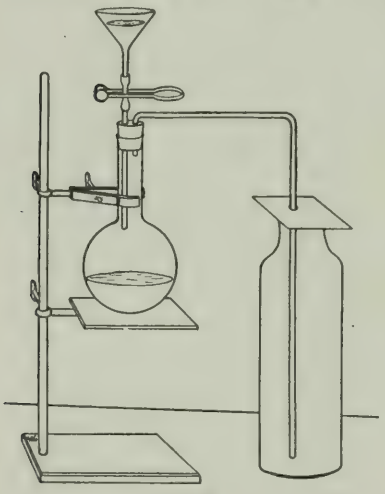


FIG 18

METHOD.

1. Fit up an apparatus as in Figure 18. Pour 25 c.c. of concentrated sulphuric acid into the flask. Make up a *saturated* solution of sodium bisulphite, pour it into the separating funnel, and allow the solution to drop into the acid at such a rate

as to generate a steady stream of the gas [1]. Collect by upward displacement of air (Technic 15) two bottles of the gas, cork, and set them aside to be used in 3 and 4.

2. Attach the stem of a thistle-tube or small funnel to the end of the delivery tube, place the wide end of the thistle-tube on the bottom of a beaker, then pour one half inch of water into the beaker, and pass the gas into the water for ten minutes [2]. Reserve this solution for 5.

3. Place in a bottle of the gas some coloured flowers or apple skin, damp litmus paper, lead-pencil and ink marks, and note any change after half an hour [3].

4. Bring bottles of hydrogen sulphide and sulphur dioxide mouth to mouth and allow the gases to mix [4].

5. To 2 c.c. of very dilute potassium permanganate solution add some of the solution from 2 [5].

6. Test the solution from 2 with litmus paper [6].

QUESTIONS: A. Why was the thistle-tube used on the end of the delivery tube in 2? B. Write equations for 1, 2, 4. C. In which of the above reactions does either the gas or its solution act as a reducer? As an acid? D. What effect would you expect sulphur dioxide to have if it were passed into a solution of sodium hydroxide? Of calcium hydroxide?

EXERCISE 37

To study sulphites

REQUIRED. Test-tubes; various sulphites, as those of sodium, potassium, and calcium, potassium permanganate, barium chloride, hydrochloric acid, sulphuric acid.

METHOD.

1. Add concentrated sulphuric acid to each sulphite and note the odour of the gas that is produced [1] (Technic 33).

2. Using distilled water, make 10 c.c. (Technic 12) of a strong solution of each sulphite and divide each into two parts. To the first part of each solution add enough potassium permanganate solution just to tinge it, and then add a few drops of an acid [2]. To the second part of each solution add a few drops of a solution of barium chloride [5] and then add a few cubic centimetres of *chemically pure* hydrochloric acid [4].

QUESTIONS: A. State three tests for sulphites. B. How does sulphurous acid differ from solutions of metallic sulphites in its action on potassium permanganate? C. Write equations for 1, and for the reaction with barium chloride and with hydrochloric acid in 2.

EXERCISE 38

To study the properties of sulphuric acid and of sulphates

REQUIRED. Test-tubes, beaker, wooden toothpick; concentrated sulphuric acid, sugar, zinc, iron, barium chloride, hydrochloric acid, nitric acid, several sulphates.

METHOD.

1. Dilute some concentrated sulphuric acid with water. With the dilute acid write on paper, using a toothpick for a pen [1]. Gradually concentrate the acid on the paper by warming the paper over a flame [2]. Try the same experiment with the concentrated acid [3]. Note also the effect of the acid on the wooden toothpick [4].

2. Make a thick syrup by heating a tea-spoonful of sugar mixed with a little water in a beaker. Then add an equal quantity of concentrated sulphuric acid [5]. This experiment should be performed over a sink.

3. Slide small lumps of iron and of zinc into separate test-tubes, add enough concentrated sulphuric acid to cover the metals. Is any gas given off? [6]

4. Prepare in three test-tubes 5 c.c. (Technic 12) of dilute solutions of sulphuric acid and of any two sulphates, using distilled water to make the solutions. To each of the three add a few drops of barium chloride solution [7]. Divide the contents of each test-tube into three parts. To the first add hydrochloric acid and boil [8], to the second add nitric acid and boil [9], and to the third add a mixture of nitric and hydrochloric acid and boil [10].

QUESTIONS: A. What is the nature of the action in 1 and 2 (**Sec. 172**)? B. What is the difference between the action of the dilute and concentrated acid on iron and zinc? C. State clearly the test for sulphuric acid and sulphates as contained in 4. D. What is the difference in the action of sulphites and sulphates toward barium chloride and hydrochloric acid (**Secs. 168 and 174**)? E. Is barium sulphate acted on by acids? F. Write equations for 4.

EXERCISE 39

To find if an unknown salt is a sulphide, a sulphite, or a sulphate

METHOD.

The teacher will supply the pupils with several unknown salts soluble in water, and the pupils will apply the tests given in Exercises 35, 37, and 38, to find whether the unknown salts are sulphides, sulphites, or sulphates.

CHAPTER XII.

ACIDS, BASES

EXERCISE 40

To study the properties of acids

REQUIRED. Test-tubes; litmus, soda, zinc dust, phenolphthalein solution, half a dozen acids, such as sulphuric, hydrochloric, nitric, oxalic, phosphoric, and acetic.

METHOD.

1. Into four test-tubes put litmus paper (red and blue), soda, zinc dust, pink phenolphthalein solution, one into each test-tube. To each test-tube add 2 c.c. of a solution of sulphuric acid (Technic 12), diluted with five times as much water [1]. Note the effects in each case.

2. Dilute sulphuric acid with 100 times as much water and cautiously taste it [2] (Technic 34).

3. Repeat 1 and 2, using instead of sulphuric acid, nitric, hydrochloric, oxalic (do not taste it), phosphoric and acetic acids [3], all except oxalic acid being diluted with 5 times as much water for 1. Use a stronger solution of oxalic acid.

4. Tabulate the results and state all the properties of acids learned from these experiments.

EXERCISE 41

To study the properties of bases

REQUIRED. Test-tubes; sodium hydroxide, ammonium hydroxide, calcium hydroxide, barium hydroxide, litmus paper, phenolphthalein solution.

METHOD.

1. Make a solution of each of the above bases and note the following properties: (*a*) taste [1] (Technic 34), (*b*) action on litmus, [2] (*c*) action on phenolphthalein solution [3], (*d*) the touch when the liquid is rubbed between the fingers [4].

2. Write out a list of the properties of bases.

CHAPTER XIII.

COMPOUNDS OF NITROGEN

EXERCISE 42

To study the properties of saltpetre and Chili saltpetre

REQUIRED. Test-tube, hard-glass test-tube, watch-glass funnel, filter paper, splint, Bunsen burner; litmus, Chili saltpetre, saltpetre, sulphuric acid.

METHOD.

1. Note the taste (Technic 34) and colour of both kinds of saltpetre [1]. Leave both exposed to the air for a few days and note which is deliquescent [2] **(Sec. 63).**

2. Test the solubility of the two saltpetres and obtain crystals of each [3] (Technic 16 and 20). Note the shape of the different crystals and make drawings of a few of each [4].

3. Slide a few crystals of Chili saltpetre into a hard-glass test-tube and heat them very intensely [5]. Test any gas that may come off with a glowing splinter inserted almost to the surface of the molten nitrate [6]. Note if any coloured gas rises. Heat the substance as long as a glowing splint indicates that a gas is coming off. Allow the residue to cool and note its appearance [7]. Retain this residue for 5. Treat common saltpetre in a similar way, also retaining the residue from it for 5 [8].

4. Slide a crystal of Chili saltpetre into a test-tube and one of common saltpetre into another. To each add enough concentrated sulphuric acid to cover the crystal [9]. Hold at the mouth of the tube moist litmus [10]. Now heat the test-tubes gently and note any effect on the moist litmus [11]. Smell very cautiously (Technic 33) any gas that may be produced [12]. Note if any liquid condenses on the side of the test-tube and if any coloured gas is produced; in order to detect small amounts of coloured gas look down rather than across the tube, so that you will look through a considerable thickness of gas [13], (but never look down a test-tube while it is being heated).

5. Treat the residues from 3 with concentrated sulphuric acid as in 4, but do not heat the test-tube. Note the colour of the gas that comes off and decide if the residue is a different substance from the original saltpetre [14].

QUESTIONS: A. One of the saltpetres is called cubic nitrate on account of the shape of the crystals. Which of the two is it? B. What gas is produced when saltpetre is heated? C. Is the residue left in 3 saltpetre or some other substance? (5) D. In 4 does any gas come off before the test-tube is heated? E. Is there any evidence that the gas that comes off is easily condensed? F. How could this gas be collected? If sulphuric acid were easily volatized could it be used to prepare this substance?

EXERCISE 43

To prepare and study the properties of nitric acid

REQUIRED. Florence flask, a one-holed cork (not rubber) to fit the flask, test-tube, gas bottle, elbow tube as in Figure 16; sodium nitrate, sulphuric acid, sulphur, barium chloride, copper tack, cotton, wool, wood, litmus.

CAUTION. *Nitric acid causes bad wounds in the flesh and is very injurious to the clothes if it comes in contact with them. The acid formed by the method of this Exercise is very strong and great care should be taken in experimenting with it.*

METHOD.

1. Arrange apparatus as in Figure 16, only substitute a Florence flask for the clamped test-tube. Slide a tea-spoonful of sodium nitrate into the Florence flask, add enough concentrated sulphuric acid to cover the crystals [1], clamp the flask, tip up as is the test-tube in Figure 16, insert the cork with the elbow tube into the flask, and pass the elbow tube to the bottom of the test-tube, which is immersed in cold water. Heat the flask just strongly enough to cause the condensed liquid to drop into the test-tube [2]. Continue the heating until the liquid ceases to be distilled. Do not heat it strongly enough to vaporize the sulphuric acid.

2. Note the odour (Technic 33) and colour of the contents of the test-tube [3].

3. Into three test-tubes put small pieces of cotton-wool, woolen yarn, and wood, one into each test-tube. Add a few drops of the liquid prepared in 1 to each test-tube [4]. Liquid from the nitric acid bottle on the reagent shelf will do. As soon as the operation is completed, throw the contents of the test-tubes into the waste jar.

4. Drop a copper tack into the liquid condensed in 1 [5].

5. Dilute a drop of the liquid with one hundred times as much water; test it with litmus and taste it [6] (Technic 34).

6. Drop a small lump of sulphur into a few cubic centimetres of the liquid and boil the mixture [7], then test the solution for a sulphate [8] (Exercise 38, 4).

QUESTIONS: A. Make a drawing of the apparatus for preparing the acid. B. Why was the Florence flask tipped in the manner indicated in the illustration? C. From its action on sulphur would you infer nitric acid is a reducer or oxidizer?

EXERCISE 44

To test for nitric acid and nitrates

REQUIRED. Test-tube; nitric acid, several nitrates, ferrous sulphate, sulphuric acid, copper tack.

METHOD.

1. Make 5 c.c. (Technic 12) of a strong solution of a nitrate and drop a copper tack into the solution [1], then add concentrated sulphuric acid, and gently warm the mixture [2]. Compare the results with those of Exercise 43, 4. Repeat this experiment, using other nitrates [3].

2. To 2 c.c. of concentrated ferrous sulphate solution add an equal quantity of dilute nitric acid and mix the two thoroughly. Now, holding the test-tube slantingly, slide an equal volume of sulphuric acid down the tube without allowing the liquids to mix [4]. Note any colour change at the boundary between the two liquids. If no colour appears allow it to stand in cold water for a few minutes and look again.

3. Repeat 2, using a nitrate instead of nitric acid [5].

4. An alternative method of using the preceding test is to put a drop of each of the liquids, sulphuric acid, ferrous sulphate, and the nitrate, on a piece of glass lying on white paper. Place the drops at the three angles of a triangle and so close that they all run together; observe their point of contact for a dark colour [6].

EXERCISE 45

To prepare and study the properties of nitrous oxide

REQUIRED. Bunsen burner, splint, Florence flask, large test-tube, one-holed rubber cork, two-holed rubber cork, elbow tube and delivery tube, pneumatic trough, gas bottle, deflagrating spoon, retort stand and clamp, splint; ammonium nitrate, roll sulphur, red phosphorus.

METHOD.

I. Arrange apparatus as in Figure 19. Slide about two tea-spoonfuls of ammonium nitrate into the flask.

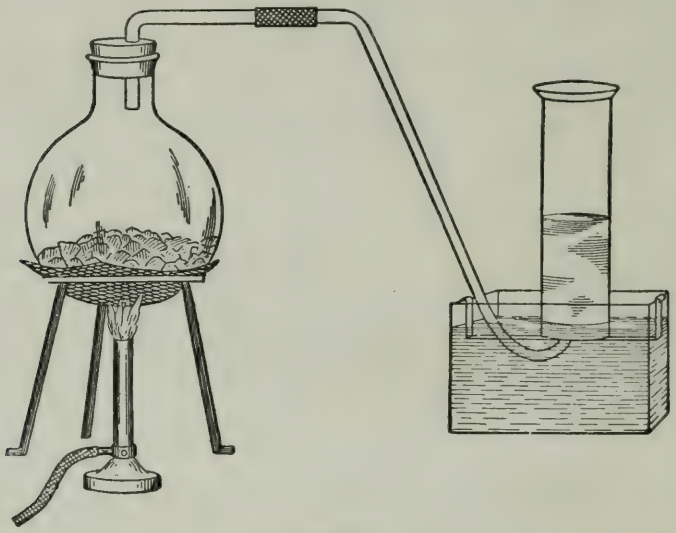


Fig. 19

Heat the flask very carefully (Technic 32) so as to allow the gas to come off at a moderate rate [1]; if brown fumes appear in the flask lessen the heating. Note the rate at which the liquid boils compared with the rate at

which gas enters the bottle [2]. Do not collect any gas until the air has been driven out. Collect over warm water 1 test-tube and 3 bottles of the gas, corking the bottles and standing them on the bench when they are full. Do not heat the flask after the molten liquid becomes low or it may explode.

2. Test the solubility of the gas in the test-tube [3] (Technic 17). Note the taste of the solution of the gas and its effect on litmus [4].

3. Insert a glowing splint into the first bottle [5]. After action ceases add 5 c.c. of water, shake, and test the solution with litmus and with lime-water [6].

4. After lining the deflagrating spoon with asbestos paper, put a small lump of roll sulphur on the spoon, just ignite it by playing on it from above with a flame, and at once insert it into the second bottle of the gas [7]. If it does not continue to burn, heat it in a flame till the sulphur is all melted and burning strongly and again insert it into the same bottle [8]. After action ceases, smell the gas in the bottle (Technic 33) and treat it as the gas in 3 was treated, omitting the lime-water [9].

5. Treat the third bottle of gas in the same way as the second bottle was treated, only use red phosphorus instead of sulphur [10].

6. Test the liquid that collects in the delivery tube with sodium and with anhydrous copper sulphate [11].

QUESTIONS: A. Make a drawing of the apparatus for preparing the gas. B. Why were the bottles of gas not allowed to remain in the water until required for experiment (**Sec. 192**)? C. Since water (6) and nitrous oxide are formed when ammonium nitrate NH_4NO_3 is heated, write the equation for the reaction. D. What products are formed in 3, 4, and 5? If nitrogen is one of the products in each case write the equations. E. What gas does nitrous oxide resemble in the properties exhibited in 3, 4, and 5? F. Which supports combus-

tion more vigorously, oxygen or nitrous oxide? Give reasons for your answer. G. Why is the amount of gas entering the bottle in 1 small compared with the vigour of the boiling in the flask? H. Does any other nitrate produce nitrous oxide when heated (**Sec. 189**)?

EXERCISE 46

To study the methods of preparing ammonia

REQUIRED. Test-tubes, hard-glass test-tube; gelatine, soda-lime, ammonium chloride, ammonium sulphate, slaked lime, sodium hydroxide, hydrochloric acid, litmus paper.

METHOD.

1. Grind enough gelatine to fill 5 c.c. of a test-tube and heat it strongly in a hard-glass test-tube [1]. Test the gas that comes off in three ways: (*a*) smell (Technic 33), (*b*) moist litmus, (*c*) by a rod dipped in hydrochloric acid brought to the mouth of the tube [2]. If the smell of ammonia is not evident repeat the experiment, using equal parts of gelatine and soda-lime. Clean the test-tube by boiling in it a strong solution of sodium hydroxide.

2. Take a little powdered ammonium chloride in one hand and a little dry slaked lime in the other, smell each [3]; then rub them together between the palms of the hands, smell the mixture on the hands [4], and bring moist litmus paper near the mixture [5].

3. Heat carefully in a hard-glass test-tube a mixture of the two substances used in 2 and apply the three tests of 1 to the gas that comes off [6].

4. Repeat 2 and 3 with ammonium sulphate and slaked lime [7].

5. Mix 2 c.c. of a strong solution of ammonium chloride with the same volume of a strong solution of

sodium hydroxide in a test-tube and heat the mixture [8]. Apply the three tests of 1 to the gas that comes off. [9].

QUESTIONS: A. Organic food materials are divided into carbonaceous and nitrogenous. To which does gelatine belong? B. Explain why the litmus turned blue. C. In 2 what means were used to promote chemical change? D. After reading Section 199 write the equations for 2, 3, and 5. E. What substances could be substituted for ammonium chloride in 2 and 5? Write the equations when the substituted substances are used. F. What could be substituted for slaked lime in 2 and 3? And for sodium hydroxide in 5? G. State a general method of preparing ammonia. H. Which of the above methods would you suggest as the best for preparing ammonia in the laboratory? I. How do sodium hydroxide and calcium hydroxide compare with ammonia in their action on litmus? J. Why is the rod in 1 dipped in hydrochloric rather than in sulphuric acid?

EXERCISE 47

To study the properties of ammonia

REQUIRED. Florence flask, evaporating dish, test-tubes, splint, one-holed rubber cork, glass tubing, rubber delivery tube, funnel; ammonium chloride, potassium hydroxide, litmus paper.

METHOD.

1. Pour into a flask about 50 c.c. (Technic 12) of concentrated ammonium chloride solution and about 25 c.c. of concentrated potassium hydroxide solution. Insert a rubber cork with a straight glass tube, heat, and collect 1 test-tube and 1 bottle full of the gas by inverting the vessels over the end of the tube. These vessels of gas are to be used in 2 and 3 as soon as they are collected. After performing 2 and 3, put one end of a rubber delivery tube on the end of the glass tube, insert into the other end of the rubber tube the stem

of a funnel or thistle-tube, then put the mouth of the funnel into an evaporating dish or beaker containing some water, and pass the gas into the water for several minutes [1]. Use this solution for 4 and 5.

2. Put a finger over a test-tube full of the gas, put the mouth of the test-tube under water, and then remove the finger [2].

3. Keeping the mouth of the bottle down, insert a burning splint into a bottle of the gas [3].

4. Pour about 5 c.c. of the solution made in 1 into an evaporating dish and test it with litmus [4]. Now add to the solution dilute hydrochloric acid, a few drops at a time, and stir the mixture after each addition until it just turns the litmus red. Evaporate the solution on a water-bath [5] (Technic 21). Note the taste of the salt, and the shape of the crystals, and compare the salt in these respects with the reagent on the shelf labelled ammonium chloride [6].

5. Boil some of the solution of ammonia and note if all the gas can be driven off by boiling [7].

QUESTIONS: A. Make a drawing of the apparatus for preparing and collecting ammonia. B. Why is the funnel put in the end of the delivery tube in 1? C. What gases that you have studied act like ammonia in 5 (**Sec. 122**)? What gases act differently (**Sec. 102**)? D. Write the equations for 1 and 4 (**Secs. 197 and 199**).

EXERCISE 48

To identify an unknown salt

METHOD.

The teacher will select several salts, either nitrates, chlorides, sulphates, sulphites, or sulphides, and the pupils by applying the tests for these will identify the salts. Refer to the text-book, Sections 113, 159, 168, 174, and 190, for the tests.

CHAPTER XIV.

THE ALKALI METALS

EXERCISE 49

To study the properties of sodium and potassium

REQUIRED. Crucible, test-tube; sodium, potassium.

METHOD.

1. Refer to Exercise 11, note the properties of sodium there observed, and write the equations [1].

2. Clean a piece of sodium (Technic 4) about the size of a pea, note the appearance of its freshly cut surface [2], and note any changes in its appearance as it remains exposed to the air. Put the cut piece of sodium away in a crucible until the next laboratory period, then note its surface [3], and cut it in two to find if it has been changed throughout [4].

3. Dissolve a little of the incrustation on the sodium in 5 c.c. of water, test the solution with litmus, and note the taste of the solution [5] (Technic 34).

4. Repeat 2 and 3, using potassium [6], *being careful not to touch it with the fingers.*

QUESTIONS: A. Why are sodium and potassium kept in kerosene? B. Why are sodium and potassium called alkali metals?

CHAPTER XV.

BROMINE AND IODINE

EXERCISE 50

To study the properties of bromine

REQUIRED. Test-tubes; bromine, alcohol, chloroform, ether.

CAUTION. *Bromine vapour is very poisonous to inhale, and liquid bromine corrodes the skin. Care should be taken that the fumes do not escape into the room.*

METHOD.

1. Place two drops of bromine in a test-tube; note the colour of the liquid and the colour and odour of the vapour [1] (Technic 33).

2. Place in 4 test-tubes 4 c.c. of distilled water, of chloroform, of ether, and of alcohol, one liquid in each test-tube. Add a drop of bromine to each test-tube and shake; note the solubility of bromine and the colour of the solution in each case [2].

QUESTIONS: A. In which liquid is bromine least soluble? Give reasons for your answer. B. Is bromine heavier or lighter than water? C. Name any other liquid element.

EXERCISE 51

To study the properties of iodine

REQUIRED. Test-tubes, Bunsen burner; iodine, alcohol, chloroform, ether, starch.

METHOD.

1. Note the colour, odour, lustre, and general appearance of iodine [1]. Drop a flake of iodine into a test-tube and gently heat it; note the odour and colour of the vapour (look down the tube), and any condensation on the side of the test-tube [2]. Examine with a lens the shape of the crystals forming the sublimate [3]. Try to melt a crystal of iodine [4].

2. Place in 5 test-tubes 2 c.c. of distilled water, of chloroform, of ether, of alcohol, and of a solution of potassium iodide, one liquid in each tube. To each liquid add a small flake of iodine and shake the contents of the tube. Note in which liquid the iodine dissolves most readily and the colour of the solution [5]. Save the alcohol solution for 3.

3. To 10 c.c. of water in a test-tube add a small pinch of powdered starch, boil the mixture, and then *cool* the liquid. Dilute it with water to form 20 c.c. Now to a test-tube nearly full of water add two drops of the alcoholic solution from 2, shake the contents, and add a few drops of this solution to the starch solution [6]. Pour out all but a few cubic centimetres of the coloured solution, boil the remainder [7], and cool it under the tap [8].

4. Repeat 3, using bromine instead of iodine [9].

QUESTIONS: A. When iodine is heated does it melt? Does it vaporize? What name is given to such a phenomenon (**Sec. 234**)? B. How can crystals of iodine be obtained? C. In which of the liquids is iodine least soluble? D. In testing iodine with starch why should the starch solution be cold?

EXERCISE 52

To prepare bromine and iodine

REQUIRED. Test-tubes, Bunsen burner; potassium bromide, potassium iodide, chlorine water (prepared

by the teacher before the lesson), starch solution, chloroform, bromine water, manganese dioxide, sulphuric acid.

METHOD.

1. Note how chlorine was prepared in Exercise 22.

2. Mix as much potassium bromide, ground fine, as will lie on a ten-cent piece with an equal quantity of manganese dioxide, place the mixture in a test-tube (Technic 26), and to the mixture add enough sulphuric acid to cover it [1]. Heat the mixture carefully [2], keeping the upper part of the tube as cool as possible; note the odour (be careful!) and colour of the vapour [3]. Note any condensation on the side of the tube [4].

3. Repeat 2, using potassium iodide instead of potassium bromide [5].

4. Make 5 c.c. of a dilute solution of potassium bromide and add to it 5 c.c. of chlorine water [6]. Heat the mixture gently, and note the colour and odour of the vapour [7].

5. Make 5 c.c. of a dilute solution of potassium iodide, add to it 5 c.c. of chlorine water, and heat the mixture [8]. Add a few drops of the mixture to some starch solution [9] and to chloroform [10].

6. Repeat 5, using bromine water instead of chlorine water [11].

QUESTIONS: A. How was hydrogen chloride formed? (Exercise 21). B. How was chlorine produced from hydrochloric acid (Exercise 22)? C. Is the preparation of bromine and iodine in 2 and 3 a combination of the method of A and B? D. Express the reaction in 2 by two equations, one expressing the reaction between potassium bromide and sulphuric acid, the other expressing the reaction between the hydride formed and manganese dioxide. Then combine the two in one equation. E. Do the same for 3. F. Write equations for 4, 5, and 6. G. How would you distinguish sodium chloride, sodium bromide, and sodium iodide?

EXERCISE 53

To identify a haloid salt

REQUIRED. Test-tube, Bunsen burner; unknown haloid salts, selected by the teacher, starch solution, chloroform, etc.

METHOD.

To be suggested by the pupils, and if approved of by the teacher, to be performed by the pupils.

CHAPTER XVI.

AGRICULTURAL EXPERIMENTS

EXPERIMENT 54

To test for sugar

Grind up thoroughly some sugar-beet or sweet fruit and shake thoroughly with water and filter. Then add dilute sulphuric acid and boil for ten minutes. Finally boil with a solution of potassium hydroxide. A brown colour is a test for sugar. Test milk and wheat for sugar.

EXPERIMENT 55

To test for starch

Grind thoroughly a piece of potato, shake it with water, filter, boil, and cool. Then add a few drops of a solution of iodine. The colour produced is a test for starch. Test the seeds of corn and flour for starch.

EXPERIMENT 56

To test for proteids

Enclose a tablespoonful of flour in a muslin bag, then hold it under a tap until the water runs off clear, working the bag all the time with the fingers. Finally open it to discover a gummy substance called gluten. Put some gluten into strong nitric acid in a test-tube and heat it. Note the colour. *Carefully* add excess of ammonia solution and note the further change of colour.

The yellow colour with nitric acid which changes to orange on the addition of ammonia solution is a test for proteids. Test white of egg, meat, and beans for proteids.

EXPERIMENT 57

To test for fats

Grind up a castor bean or peanut, add ether and shake. Then place one drop of the solution on white paper. As the ether evaporates the fat leaves a grease spot on the paper. This is a test for fats. Test bananas, sunflower and flax seeds for fats.

EXPERIMENT 58

To test soil for acidity

Obtain soil from various places, such as a marsh or swamp, a meadow, and a kitchen garden. Stir some of the soil into rain or distilled water and test with litmus. Then mix with each of the soils a little slacked lime and again test with litmus.

EXPERIMENT 59

To test the effect of lime on the texture and structure of clay

Measure into each of three pans a pint of clay soil. Add to the first a tablespoonful of slaked lime, to the second two tablespoonfuls, and to the third none. Add enough water to mix them to a thick dough, and make each into a ball and set away to dry. Then compare their surfaces; break them to pieces, and compare their structure and hardness.

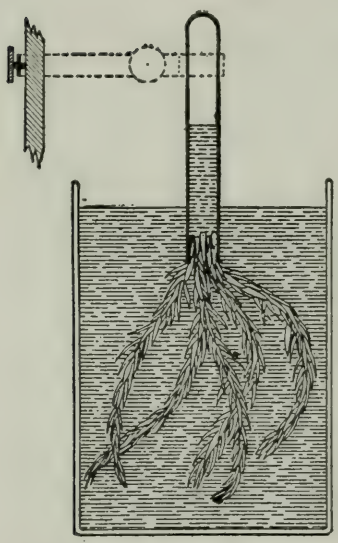
EXPERIMENT 60

To show the respiration of growing seeds

Half fill a bottle with soaked peas mixed with small pieces of wet sponge clippings. Bend a glass tube twice at right angles, insert one arm in a rubber cork, which is then used to stop the bottle. Set the other arm deep into a test-tube containing lime-water. Set the apparatus in a warm place and notice the bubbles of gas given off and their effect on the lime-water. After two days remove the cork from the bottle and quickly insert a blazing splinter.

EXPERIMENT 61

To show the process of photo-synthesis



Arrange apparatus as in Figure 20. Aquatics, such as Canada water-leaf or water-cress, are placed in the beaker full of water. The apparatus is left in the sunlight. Watch for bubbles rising from the broken ends of the water plants, and when the test-tube is two-thirds full test it with a glowing splinter. Repeat the experiment, boiling and cooling the water before putting it into the beaker.

THE PRICE OF REAGENTS

Acetic Acid	per	pound	$0.10
Alcohol	"	gallon	3.00
Alum	"	pound	.10
Aluminium	"	"	1.00
Ammonium chloride	"	"	.25
Ammonium hydroxide	"	"	.15
Ammonium nitrate	"	"	.25
Ammonium sulphate	"	"	.30
Animal charcoal	"	"	.10
Antimony	"	"	.25
Barium chloride	"	"	.20
Barium dioxide	"	"	.35
Benzine	"	gallon	.20
Blue vitriol	"	pound	.15
Bon-ash	"	"	.10
Bromine	"	ounce	.25
Calcium	"	pound	1.50
Calcium carbide	"	"	.30
Calcium carbonate	"	"	.10
Calcium chloride	"	"	.20
Calcium hydroxide	"	"	.10
Calcium sulphite C. P.	"	"	.40
Carbon bisulphide	"	"	.15
Chloride of lime	"	"	.10
Chloroform	"	"	.35
Common salt	"	"	.01
Copper foil	"	"	1.20
Copper oxide	"	"	.50
Copper sulphate anhydrous	"	"	.75
Epsom salts	"	"	.10
Ether	"	"	.75
Ferrous sulphate	"	"	.10
Ferrous sulphide	"	"	.15

Gelatine	"	"	$0.50
Graphite	"	"	.10
Gypsum	"	"	.10
Hydrochloric acid	"	"	.04
Indigo carmine	per	ounce	.30
Iodine	"	"	.25
Iron filings	"	pound	.10
Lead	"	"	.20
Lead nitrate	"	"	.15
Magnesium	"	ounce	.20
Megnesium carbonate	"	pound	.30
Magnesium chloride	"	"	.10
Manganese dioxide	"	"	.10
Marble (see calcium carbonate)			
Mercuric oxide	"	"	1.20
Mercury	"	"	.80
Nitric acid	"	"	.09
Oxalic acid	"	"	.12
Phosphorus	"	"	.90
Phosphoric acid	"	"	.20
Potassium	"	ounce	1.25
Potassium carbonate	"	pound	.12
Potassium chloride	"	"	.15
Potassium hydroxide	"	"	.15
Potassium permanganate	"	"	.20
Potassium sulphite	"	"	.30
Pyrogallic acid	"	"	.20
Red lead	"	"	.10
Saltpetre	"	"	.10
Silver nitrate	"	ounce	.50
Soda-lime	"	pound	.35
Sodium	"	ounce	.20
Sodium bicarbonate	"	pound	.10
Sodium bisulphite	"	"	.15
Sodium carbonate	"	"	.10
Sodium chloride	"	"	.10
Sodium hydroxide	"	"	.15
Sodium nitrate	"	"	.10
Sodium nitrite	"	"	.20
Sodium sulphate	"	"	.10
Sodium thiosulphate	"	"	.10

Stannous chloride	"	"	$0.50
Starch	"	"	.10
Sulphur	"	"	.10
Sulphuric acid	"	"	.04
Tin	"	"	.60
Turpentine	"	"	.10
Washing-soda (see sodium carbonate)			
Zinc	"	"	.20
Zinc chloride	"	"	.15
Zinc dust	"	"	.15
Zinc oxide	"	"	.15

NOTE: These prices were pre-war prices. As soon as they are again stable this list will be corrected.

Data regarding Elements mentioned in this Volume

NAME	Symbol	Approximate Atomic Weight	Valency
Aluminium	Al	27	III
Antimony	Sb	120	III, V
Argon	A	40	0
Arsenic	As	75	III, V
Barium	Ba	137	II
Bromine	Br	80	I
Caesium	Cs	133	I
Calcium	Ca	40	II
Carbon	C	12	IV
Chlorine	Cl	35.5	I
Copper	Cu	63.6	I,II
Fluorine	F	19	I
Gold	Au	197	I, III
Helium	He	4	0
Hydrogen	H	1	I
Iodine	I	127	I
Iron	Fe	56	II, III
Krypton	Kr	83	0
Lead	Pb	207	II
Lithium	Li	7	I
Magnesium	Mg	24	II
Manganese	Mn	55	II, IV
Mercury	Hg	200	I, II
Neon	Ne	20	0
Nickel	Ni	58.7	II
Niton	Nt	222.4	0
Nitrogen	N	14	III, V
Oxygen	O	16	II
Phosphorus	P	31	III, V
Platinum	Pt	195	IV
Potassium	K	39	I
Radium	Ra	226	II
Silver	Ag	108	I
Sodium	Na	23	I
Strontium	Sr	87.6	II
Sulphur	S	32	II, IV, VI
Tin	Sn	119	II, IV
Xenon	Xe	130	0
Zinc	Zn	65	II

Table of Solubilities

	Aluminium	Ammonium	Antimony	Arsenious	Barium	Calcium	Copper	Ferrous	Ferric	Lead	Magnesium	Manganese	Mercurous	Mercuric	Potassium	Sodium	Silver	Zinc
Bromide	S	S	Ss	S	S	S	S	S	S	Ss	S	S	I	S	S	S	I	S
Carbonate	....	S	....	....	I	I	I	I	....	I	I	I	I	I	S	S	I	I
Chlorate	S	S	....	....	S	S	S	....	....	S	S	....	S	S	S	S	S	S
Chloride	S	S	Ss	S	S	S	S	S	S	Ss	S	S	I	S	S	S	I	S
Hydroxide	I	S	Ss	S	S	Ss	I	I	I	I	I	I	....	I	S	S	....	I
Iodide	S	S	Ss	Ss	Ss	S	....	S	....	I	S	S	I	I	S	S	I	S
Nitrate	S	S	....	....	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Oxide	I	....	Ss	S	I	Ss	I	I	I	I	I	I	I	I	S	S	I	I
Phosphate	I	S	....	....	I	I	I	I	I	I	I	Ss	I	I	S	S	I	I
Sulphate	S	S	....	....	I	Ss	S	S	S	I	S	S	Ss	S	S	S	Ss	S
Sulphide	....	S	I	I	S	Ss	I	Ss	....	I	S	I	I	I	S	S	I	I
Sulphite	....	S	....	....	I	Ss	S	Ss	....	I	Ss	....	....	....	S	S	S	Ss

S=Soluble in water I=Insoluble in water. Ss=Slightly soluble in water.

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